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JOURNAL OF THE AMERICAN WELDING SOCIETY

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American Welding Society

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JOURNAL
OF THE
AMERICAN WELDING SOCIETY

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Engineers' Club, 2 Commonwealth Ave., Boston, Mass.
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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. 2. JANUARY, 1923. NO. 1

TREASURER OF THE AMERICAN WELDING SOCIETY

The members of the American Welding Society will regret to learn of the resignation of our esteemed Treasurer, Mr. Symons who has felt for a long time that he should be relieved, because of numerous other duties, of the office of Treasurer which he has faithfully filled since the formation of the Society. The Board of Directors out of respect for his wishes and knowing that many times in the past the generous giving of his time involved considerable personal sacrifice, accepted his resignation.

Mr. T. E. Barton, Master Mechanic, of the Delaware, Lackawanna and Western Railroad has been appointed to fill the unexpired term. The Society is indeed fortunate in being able to secure Mr. Barton's services. He is well known to the Society, having served in the capacity of Chairman of the New York Section and has also been active in securing new members. The railroad with which he is connected, through his efforts, is now able to report that all of its welders are members of the Society.

AMERICAN WELDING SOCIETY DIRECTORY

In the compilation of the first Directory of the American Welding Society, a blank card has been sent to all members in order to secure exact information as to business connection and address. Cards should be filled in and returned promptly to the Secretary.

EMPLOYMENT SERVICE BULLETIN

The Journal contains an Employment Service Bulletin. The bulletin is divided into two sections—Positions Vacant and Services Available. No charge is made either to the available engineer, foreman or welder or to the organization seeking welding talent. Excellent service has been rendered by the Society in this capacity. However, it has come to our attention that some members are not making full use of the opportunities offered thru this bulletin. If you are out of employment or if you desire to secure welding talent, you should notify the Secretary at once. In the latter case, the location, necessary qualifications for each position, and approximate salary, if possible, should be stated.

WELDERS—ATTENTION!

The Society desires to include in its Journal, descriptions of various welding jobs. Members are urged to send in brief descriptions of difficult and important jobs successfully completed. Enough details should be given in each case to enable another welder to duplicate the work. Illustrations and photographs are helpful.

Discussions of papers appearing in our Journal are particularly invited. You may not agree with the author in certain deductions or contentions, or possibly you can supplement the information given from your own experience. If so, it is your duty to supply this information for the general good of the art.

THE SAME MAY BE SAID OF THE AMERICAN WELDING SOCIETY

The following editorial is taken from the December 12, 1922 issue of POWER bearing on the A.S.M.E. It would be equally applicable to the American Welding Society:

"None of us liveth to himself alone." This is as true in the professions as it is in family and communal life.

The practitioner who secludes himself from other members of his profession, who liveth unto himself alone and loses himself in the details of his local activities will never get beyond Main Street.

Every good citizen should regard himself not as an individual out to make the best possible living for himself, but as a unit in the great Brotherhood of Man,

directing his talents and his energy toward the success of the race in its struggle with its environment and in its onward and upward development. The more he does to this end, the more he will stand out among his fellows and the greater recognition he will gain.

It is true that many outstanding examples of acquisition owe their fortunes with their accruing privileges and prerogatives to customs and practices which bestow no service upon their fellowmen. It is true that many are tempted to emulate them rather than to win credit and preferment by real service.

Their success would impede rather than advance the general well-being.

No class is better circumstanced to carry out this idea of service than the engineer whose province it is to control and adapt the forces and materials of nature to the use and benefit of man.

And the engineer can do this through organized collective effort to better advantage than he can individually.

The American Society of Mechanical Engineers, which held its annual meeting recently is one of the professional societies which has this idea of service foremost in mind. No organization can be greater than the ideals of its leaders, but service to the profession and through the profession to the public is the motivating idea in the administration of this society. It deserves the co-operation and support of every qualified member of the profession; not simply the joining of it and paying its dues, but by an active participation in the work which it is doing to help engineers help humanity."

PROGRESS REPORT OF COMMITTEE ON WELDED RAIL JOINTS

In a recent issue, announcement was made of the appropriation of funds by the American Electric Railway Association and the offer of several large electric railway companies to contribute various amounts to finance a series of constructive tests to develop the several types of welded rail joints to their highest degree of efficiency. The importance with which the proposed research work is regarded by the industry is evidenced by the prompt response of the companies invited to contribute to this fund. The following is a list of the companies that have promised to contribute; in fact contributions already have been received from most of these:

Boston Elevated Railway Company.
Chicago Surface Lines.
Community Traction Company.
Connecticut Company.
East St. Louis Railway Company.
General Electric Company.
Illinois Traction System.
Indianapolis Street Railway Company.
Louisville Railway Company.
Metropolitan West Side Elevated Railway Company.
The Milwaukee Electric Railway and Light Company.
Pennsylvania-Ohio Electric Company.
Philadelphia Rapid Transit Company.
Public Service Railway Company.
Terre Haute, Indianapolis & Eastern Traction Company.
Third Avenue Railway Company (Dry Dock East Broadway & Battery R. R. Company).
Union Traction Company of Indiana.
United Railways and Electric Company of Baltimore.
United Railways of St. Louis.
Westinghouse Electric & Manufacturing Company
Metal and Thermit Corporation.

The research work will be carried out under the direction of the Committee on Welded Rail Joints of the American Welding Society, the American Electric Railway Engineering Association and the National Research Council. This Committee has a membership at the present time of about 60 individuals, a majority of whom are electric railway engineers. Included in the personnel, are representatives of companies manufacturing rails, rail joints and electrical apparatus and also representatives of technical universities and testing laboratories. The committee is thoroughly representative of the various interests concerned and functions through an Executive Committee, the members of which are:

Dr. G. K. Burgess, *Chairman*,
Division of Metallurgy, Bureau of Standards, Washington, D. C.

E. M. T. Ryder, *Vice-Chairman*,
Way Engineer, Third Avenue Railway System, New York, N. Y.

W. Spraragen, *Secretary*.
Secretary, Division of Engineering National Research Council, New York, N. Y.

C. A. Adams,
Professor of Electrical Engineering, Harvard University, Cambridge, Mass.

R. C. Cram,
Engineer, Surface Roadway, Brooklyn, Brooklyn Rapid Transit Company, Brooklyn, N. Y.

E. J. Mellraith, Supt.
Rolling Stock and Buildings, Philadelphia Rapid Transit Company, Philadelphia, Pa.

H. M. Stewart, Supt. of Maintenance. Boston Elevated Railway, Boston, Mass.

G. L. Wilson, Engineer, Maintenance of Way, Minneapolis Street Railway Company, Minneapolis, Minn.

W. W. Wysor, Chief Engineer, United Railways and Electric Company, Baltimore, Maryland.

G. C. Hecker, Special Engineer, American Electric Railway Association, New York, N. Y.

Close co-operation is being maintained with the committee on Way Matters of the American Electric Railway Engineering Association through its sub-committee on Arc Welded Joints. The Committee on Welded Rail Joints will report every six months to the American Electric Railway Engineering Association, the amount of funds appropriated and expended and the funds available for use. In each report will be included a brief statement of the progress and status of the work. Disbursment of funds will be made by requisition or bill signed by a member of the Committee on Welded Rail Joints, representing the American Electric Railway Engineering Association and approved by a designated member of the Executive Committee of the American Electric Railway Engineering Association after which such bills will be presented to the Executive Secretary of the American Electric Railway Association for formal approval in the usual manner.

The Executive Committee of the Committee on Welded Rail Joints held a meeting on November 13th, at which details of the program were discussed. In addition to the service tests to be made on the proposed rotary testing machine, there will be physical, metallurgical and chemical tests of specimens. The most important of the physical tests will be the bending test, drop test, tensile test and repeated impact test. Both drop and repeated tests are shock tests as distinguished from the others which are strain tests. It is well known that a material may have a very high resistance to strains and at the same time an extremely low resistance to shock.

It is probable that the bending tests will be conducted at Purdue University under the supervision of Professor D. D. Ewing. It is planned to carry these tests to destruction so that a study may be made of the actual joint failures, in addition to determining the relative strength of the joints.

The University of Illinois has offered to make the first set of drop tests without charge to the Committee. The tensile tests will be made at the Bureau of Standards. The Bureau is equipped with an Emery testing machine of 1,150,000 lb. capacity in tension, which can be used by the addition of auxiliary heads to grip the rails. The design of the auxiliary heads has been decided upon and they will be purchased by the Committee on Welded Rail Joints from the Bethlehem Steel Company.

Mr. W. W. Wysor, Chief Engineer, United Railways and Electric Company, Baltimore, Maryland, has been appointed Chairman of a sub-committee to design a rotary service testing machine following in general, the design shown in the report of the Committee on Way Matters of the A. E. R. E. A., for 1922. A number of very interesting factors enter into the design of such a machine among which may be mentioned the enormous centrifugal force which will be developed, the effect of sprung and unsprung weight, the question of braking, whether flanged or flangless wheels shall be used, and the manner of constructing and safeguarding the observation pit. The organization of this sub-committee is now under way and it is expected that tentative plans will be submitted at an early date.

With such a machine as this, it is expected that in a month's time, the joints installed in the circular track can be given a service test equivalent to, from three to ten years ordinary street railway service.

Mr. E. J. McIlraith has been appointed Chairman of a sub-committee to design a repeated impact testing machine. Mr. McIlraith has made extensive investigations of this character in Philadelphia. It is probable that some standard type of ore breaking machine will be used as a basis of the proposed design with such modifications as may seem desirable to adapt it to the rail joint tests. The impact machine will be designed to deliver the same blow as closely as possible as an average car wheel under average loading through a drop equivalent to ¼ inch drop on a bad joint.

A satisfactory solution of the problems before the committee may depend in large measure on metallurgical investigation of the metal in the welded area. The Chairman of the committee, Dr. G. K. Burgess, is Chief of the Division of Metallurgy of the U. S. Bureau of Standards. The rotary testing machine is to be located on the ground of the Bureau and it is expected that with such close association of the work with the

technical staff of the Bureau it will prove of great advantage.

The Committee has proceeded in its work with an earnestness that promises well for the outcome of the proposed tests and in spite of the many difficulties to be overcome in the development of the present types of welded rail joints, it is believed that substantial progress may be expected. As the work develops, it is possible that the personnel of the Committee will be expanded to include other experts and representatives of other interests concerned. An invitation already has been extended to the American Railway Engineering Association to appoint a representative on the committee and to co-operate fully in the work. This will give the steam railroad engineers a connection with the work through their own association. Their chief interest would probably be in the possibility of testing bolted rail joints in the proposed rotary service testing machine and it is probable that this machine will be so designed as to permit tests to be made on M.C.B. Standards also.

It is the thought of the committee that after the welded rail joint tests are completed, it may be found desirable to use the service testing machine for other important research work such as the testing of journal boxes, bearings and other similar equipment. At the present state of development of the work of the committee it is particularly important to have comments and suggestions from all interested parties covering both the general progress of the committee's work and the details of the apparatus and tests. Such comment may be made directly to the heads of the various subcommittees whose names are mentioned above or directly to the Secretary of the Committee.

SECTION ACTIVITIES

Boston

The following items are included in the program of the meeting of the Boston Section, to be held at the River Works Plant of the General Electric Company at West Lynn, Mass., on January 19th,

2:00 p. m. to 3:00 p. m.—Reception of Members and Guests at Theatre Building.

3:00 p. m. to 3:20 p. m.—Address of Welcome, Nelson J. Darling, Manager River Works.

3:25 p. m. to 4:00 p. m.—Practical Welding Demonstrations, Welding Dept. Building 41.

Return to Theatre Building.

4:10 p. m. to 4:20 p. m.—Address by Prof. Elihu Thomson.

4:20 p. m. to 4:30 p. m.—Address by Prof. A. S. Kinsey.

4:30 p. m. to 5:45 p. m.—Moving Picture, "The Making of an Automobile in an up-to-date Factory."

5:00 p. m. to 7:00 p. m.—Luncheon and Social Hour, Restaurant-Administration Building.

7:30 p. m. to 8:00 p. m.—Mr. P. O. Noble, "Automatic Arc Welding."

8:10 p. m. to 8:30 p. m.—Prof. C. A. Adams on "The Importance of Research to the Development of the Welding Industry."

8:30 p. m. to 10:00 p. m.—Mr. C. A. McCune a talk on the "Manufacture of Welding Wire," with Moving Pictures, Illustrating the Various Processes.

Chicago

A meeting of the Chicago Section is scheduled for Friday Evening, January 12th. The program calls for an Arc Welding Session to discuss the following problems:

1st—Under what circumstances is it advisable to preheat cast iron welds which are to be made with the electric arc?

2nd—To what extent is brazing by the electric arc practicable?

3rd—How do you estimate the time required to make an electric arc weld?

4th—What is the quickest method of training arc welders?

5th—What is the cost per hour of operating a motor truck outfit?

6th—What are some of the tests which can be made to demonstrate the value of arc welding without the use of laboratory facilities or scientific instruments.

7th—What is the best method of keeping a motor truck outfit busy on outside work?

New York

A meeting of the New York Section will be held on January 16th in Room 2, of the Engineering Society Building at 8 p. m. Mr. E. S. Eldridge, Welding Foreman, Kingsland Shops, Delaware, Lackawanna & Western Railroad, will pre-

sent a paper on "Practical Welding." The meeting will be turned over to welders for discussion.

Northern New York

The Northern New York Section held a joint meeting with the local section of the A. S. M. E. in Edison Club Hall on December 8th. Preceding the meeting, a moving picture was shown illustrating:

1st—Various operations necessary in the making of the largest lead-covered steel armored cable in the world.

2nd—Making of the largest insulator in the world.

3rd—The operation of the largest electrically driven shovel in the world, and

4th—The cutting of a 36" steel plate with the oxy-hydrogen flame.

Professor McKibben presented a paper on "Arc Welding as Applied to Steel Structures." Professor McKibben described in detail the present method of making riveted joints in bridge structures and the proper way of making the same joints by electric welding. Slides were used to illustrate the difference in design.

This meeting attracted considerable attention and many out of town bridge designers were present. Among them were included:

Thos. Earle, Bethlehem Steel Co., Bethlehem, Pa.
G. L. Taylor, Ch. Engr., McClintic-Marshall Co., Pittsburgh, Pa.
F. E. Schall, Bridge Engineer, Lehigh Valley R. R. Co., Bethlehem, Pa.
Clyde MacCormack, Chief Engineer, The Phoenix Bridge Co., Phoenixville, Pa.
Aubrey Weymouth, Post and McCord Co., 101 Park Ave., New York.
G. W. Kittredge, Ch. Engineer, New York Central R. R. Co., Grand Central Terminal, New York.
J. H. Edwards, Assistant Chief Engineer, American Bridge Company, New York.
F. L. Castleman, Engineer, American Bridge Company, Pencoyd, Pa.
Henry W. Preston, Engineer, American Bridge Company, Elmira, N. Y.
H. W. DeGraff, Engineer, American Pipe and Construction Co., Schenectady, N. Y.
James F. Small, Manager, American Construction & Dredging Co., Schenectady, N. Y.
Howard F. Bennett, Manager, Dubois-Bennett Construction Co., Schenectady, N. Y.

San Francisco

A meeting of the San Francisco section was held on December 8th. Mr. H. J. McCracken, District Boiler Inspector of the Southern Pacific Railway, presented a paper on "Autogeneous Welding" at their Sacramento General Shops. About 70 were in attendance.

NEW MEMBERS FOR THE MONTHS OF OCTOBER, NOVEMBER AND DECEMBER

Boston

	Class
Dr. D. A. Krebs, Treasurer General Welding and Equipment Co.	A
H. Clausen, Lt., Engineer, Royal Danish Navy, 353 Massachusetts Ave., Cambridge, Mass.	B
J. A. Shand, Manager, Air Reduction Sales Co., Dorchester, Mass.	C
H. O. Westendarp, Salesman, General Electric Co.	B
R. T. Evans, Foreman, General Electric Co., Wakefield, Mass.	C
H. A. Johnson, Foreman, Riverside Boiler Works, Cambridge, Mass.	C
A. E. Luce, Dept. Head, Mechanical Div., Dennison Mfg. Co., Framingham, Mass.	C
F. A. Peterson, Leading Hand, General Electric Co., Lynn, Mass.	C
N. L. Shuver, Steel and Welding Wire Salesman, 17 King Terminal, Boston, Mass.	C
H. A. Sodirberg, Welder, General Electric Co., Lynn, Mass.	C
W. W. Webb, Foreman Machinest, Dover Stamping & Mfg. Co., Cambridge, Mass.	C
E. Brooking, Welder, 67 Ashland Street, Lynn, Mass.	D
C. E. Littlefield, Mass. Inst. of Technology, Cambridge, Mass.	D
R. E. Locke, Welder, B. & M. R. R., Charlestown, Mass.	D
C. L. MacLean, Acetylene Welder, 19 Endicott Ave., W. Somerville, Mass.	D
D. H. Miller, Acetylene Welder, 43 Brookline Ave., Brookline, Mass.	D
Chas. Morrison, Dyer, 155 Brookline Street, Cambridge, Mass.	D
E. J. O'Neil, Welder, 29 School Street, Lynn, Mass.	D

L. A. Price, Welder, B. & M. R. R., 13 Winchester Place, Winchester, Mass. ..... D
E. A. Sadler, Gas Welder, General Electric Co., West Lynn, Mass . D
A. J. Swanberg, Watertown Arsenal 21 Astor Street, Boston, ... D

Chicago

J. M. Jardine, Proprietor, Western Welding & Equipment Co. .... B
E. L. Mills, Sales Mgr., The Bastian-Blessing Co. ..... B
G. R. Anderson, Welding Demonstrator, General Electric Co. ... D
L. Bundzinski, Acetylene Welder 1026 N. Winchester Ave. ..... D
Ben. Egan, A. T. & S. F. Scrap Yard, Corwith, Ill. ..... D
Ralph Feller, Arc Welder, Illinois Steel Co., 7101 Woodlawn Ave. . D
M. Feno, Acetylene Welder, Santa Fe R. R., 4959 So. Hoyne Ave., Chicago, Ill. ..... D
W. C. Harr, Welder, A. T. & S. Fe R. R., 3119 W. 38th Street ..... D
N. Hoffman, Welder, A. T. & S. Fe R. R., 5140 Archer Avenue .... D
Julian Johnson, Welder, A. T. and S. Fe R. R., 1738 Stuben St. .. D
C. W. Purnell, Jr., Salesman, Acme Oxygen Co., 431 So. Dearborn St. D
Wm. Sagan, Acetylene Welder, S. Fe R. R., 5317 So. Honore St. .. D
Thos. Salack, Welder, A. T. & S. Fe R. R., 930 W. 29th Street, ... D
John Shakon, Welder, Brunswick, Kroeschelle Co., 442 W. Erie St. D
Henry Thielen, Arc Welder, Illinois Steel Co., 7012 Dorchester Street D

Los Angeles

Jos. X. Smith, Sales Engr., Oxweld Acetylene Co., 1310 Santee Street B
E. H. Glasgon, Electric Welder, P. E. R. R., Hotel Norwood, ... D

New York

J. L. Anderson, Industrial Engr., Air Reduction Sales Co. ..... B
T. F. Barton, M. M., Delaware, Lackawanna & Western R. R., Kingsland, N. J. ..... B
A. R. Luechinger, Terminal Engineering Co., 612 West 44th St. B
F. V. McGinness, President, Transportation Engineering Corp. C
M. Nakasima, Welding Operator, N. O. G. N. R.R. Co., Bogalusa, La. C
David Randall, Oxy-Acetylene Welder, 875 DeKalb Ave., Brooklyn . C
John Gill, Car Foreman, Delaware, Lackawanna & Western R. R., Kingsland, N. J. ..... D
Raymond Jacobus, Welder, Delaware, Lackawanna & Western R. R. Kingsland,, N. J. ..... D
Jos. McQuire, Foreman, Delaware, Lackawanna & Western R. R., Kingsland, N. J. ..... D
C. W. Osback, Tinsmith Foreman, Delaware, Lackawanna & Western R. R., Kingsland, N. J. ... D

Northern New York

G. W. Swan, Sales Agt., 500 Morgan Bldg., Buffalo, N. Y. ..... B
Chas. Haeusser, Prop., N. A. Welding & Repair Wks., 649 N. Pearl St., Albany, New York, ... D

San Francisco

E. S. Anderson, Production Mgr., Anderson-Barngrover Mfg. Co., 333 W. Julian St., San Jose, Cal. B
J. H. Janusch, California Compressed Gas Co., 94 Stewart St. C
C. E. Moulux, California Compressed Gas Co., 1135 3rd St., Oakland, Cal. C
D. J. Will, California Compressed Gas Co., 1135 3rd St., Oakland, Cal. C
Carl Burley, Acetylene Welder, 3782 Manila St., Oakland, Cal. .. D
A. D. Coutre, Elec. Welder, P. O. Box 14, San Bruno, Cal. ..... D
E. Cullen, Acetylene Welder, Brown Bros. Welding Co., 66 CasselliAve. D
S. O. Fales, Welder, Brown Bros., 223 Main Street ..... D
Ralph Foster, Elec. Welder, Brown Bros. Welding Co., 223 Main St. D
M. C. Hansen, Acetylene Welder, Brown Bros. Welding Co., 223 Main Street ..... D
G. J. Monaco, Acetylene Welder, 2189 Howard Street, ... D
Geo. Skipton, Commercial Engr., Westinghouse Elec. & Mfg. Co. D
Martin Sorensen, Sheet Metal Foreman, Anderson-Barngrover Mfg. Co., 333 W. Julian St., San Jose, Cal., ... D

(Not in Sections)

R. H. Dalgleish, Chief Engineer, The Capital Traction Co., 36th & M Sts., N. W. Washington, D. C. ..... A
G. C. Estill, Engr., Way and Structures, New Orleans Public Service Inc., 201 Baronne St., New Orleans, La. ..... A
Augustine Davis, Jr., President, The Davis Welding & Mfg. Co., 1543 Queen City Ave., Cincinnati, O. B
E. V. Bain, Manager, Garage and Machine Shop, Reidsville, N. C. C
W. V. Gilpin, Oxy-Acetylene Welder, Tucson Gas Co., Tucson, Ariz. D
E. J. Jabant, Acetylene and Thermit Welder, Central Vermont R. R., St. Albans, Vt. ..... D

EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society maintains an Employment Service Bulletin. This service is particularly needed in the present business readjustment. The bulletin is divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The cooperation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Journal of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the Thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

SERVICES AVAILABLE

A-16 ENGINEER: Executive, engineer and sales ability; connected with industry ten years in capacity supervisor, engineer and salesman. Developed line gas welding and cutting equipment for prominent manufacturer. Familiar gas and electric processes. Open for position within the industry, preferably as sales engineer. Member A. W. S., Association, Member A. S. M. E. Age 31, available to travel or locate anywhere.

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office.

Price, gold-filled, 75c., 14-K. gold, $5.00.

AUTOGENOUS WELDING AT SACRAMENTO GENERAL SHOPS OF THE SOUTHERN PACIFIC COMPANY*

H. J. McCRACKEN† AND F. J. HICKEY.

During the last few years an unusually rapid advance has been made in both electric arc and oxy-acetylene welding and they have now become recognized as an art very essential to many industries—particularly the railway industry.

The field for both electric arc and oxy-acetylene welding is unlimited; practically every industry employing iron and steel or alloys can use it to advantage not only for joining two pieces of metal, but also for cutting, building on, or adding to other metal parts. It is widely used throughout those branches of the metal industry in which work is done on iron or steel in rolled cast or fabricated forms. New fields for its successful use are being discovered every day. Familiar examples of this class of work are ship construction, the manufacture of air reservoirs, tanks, boilers, automobile frames, machine tools and hundreds of other applications.

Excellent economies have been affected by the use of these processes especially when employed in quantity production and in making repairs to the vast number of parts that fail in railway service.

One instance of the application of welding on the Southern Pacific Railway is the making of *car end sills* for repairs to steel cars. These have deep flanges and are of irregular shape. It would be a difficult and expensive operation to flange these sills by hand, we therefore cut out a Vee in the flanges with the cutting torch. The first or straight bend is made with the rolls, then the short bends are made causing the flange to close up where it had been cut out and finally it is welded either by the electric arc or oxy-acetylene process, making a very substantial and economical job. (See Fig. 1).

TUBE SHOP.

In the tube shop, hundreds of boiler tubes of various sizes and lengths are repaired daily. Autogeneous welding makes it possible to reclaim many tubes which otherwise on account of the deep pitting, it would be necessary to scrap. They are made practically good as new by filling in the pits with either the oxy-acetylere or electric arc process. (See Fig. 2).

Many of the larger size tubes from 4" to 5½" diameter that are beyond repair because of excessive pitting are split the full length of tube with the oxy-acetylene torch and flattened out. The plate thus obtained from the tube is used for various purposes.

*Presented at December, 1922 Meeting, San Francisco Section, A. W. S.
†District Boiler Inspector, Southern Pacific Railway.

Practically all the larger tubes scrapped are reclaimed in this manner.

Oil drums sent in for repairs are sometimes so badly dented, by coming in contact with heavy bodies, that we find it impossible to straighten the dents with internal hydraulic pressure. It is therefore necessary to cut off one end of the drum with the

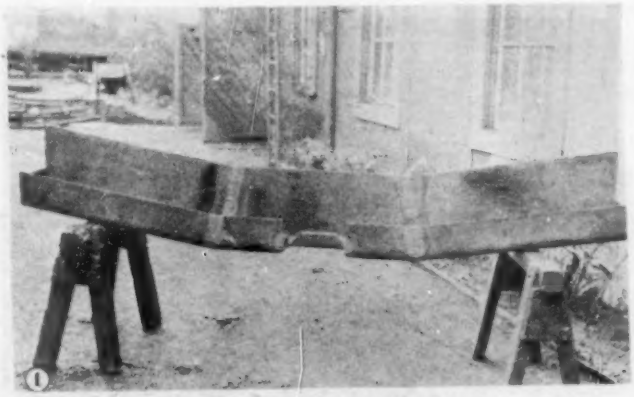

Fig. 1. Sheet Steel End Sill Electric Welded

oxy-acetylene torch and straighten them by physical effort. After the drum is straightened the end is fitted back to its original position and welded with either the oxy-acetylene or electric process. This makes a strong durable job and the cost is well within the limits of the original price of the drum. (See Fig. 3).

In making repairs to metal pilots, the cutting torch is employed extensively in separating the structure. If the rivets are cut off with sledge and chisel, a decided loss would ensue through damage of the light material caused in cutting off and backing out rivets.

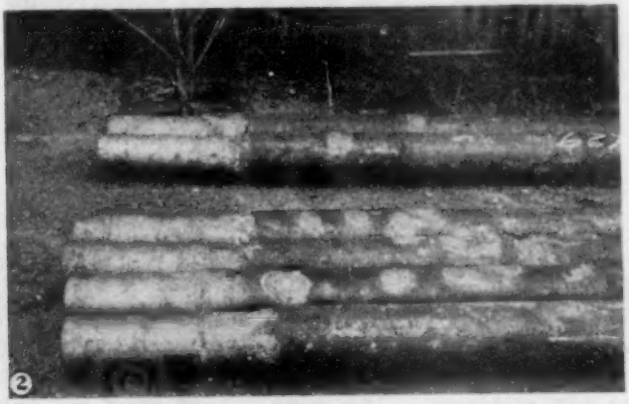

Fig. 2. Superheater Flues Reclaimed by Electric Welding.

Fig. 4 shows a pilot where the rivets have been cut off. It is now ready to dismantle and straighten.

We also manufacture in this department, tanks, foundry ladles, structural shapes, etc. Welding is employed where ever possible instead of riveting and other methods of joining the metal parts. One or more welding outfits are constantly employed in this shop.

Fig. 3. Metal Barrels Reclaimed by Electric Welding.

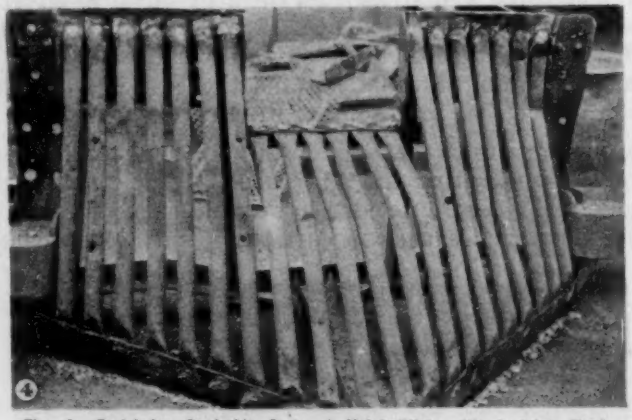

Fig. 4. Reclaiming Servicable Parts of Metal Pilots with Acetylene Torch.

BOILER REPAIRS

The boiler shop offers an extensive field for both the oxy-acetylene and arc welding processes. For example, a locomotive boiler is sent in for repairs. The inside fire box must be removed as quickly as possible. Instead of cutting it out as we were formerly forced to do with drills, hammers and chisels, the oxy-acetylene process is now employed. The work is performed not only quick-

er and cheaper, but with less labor and with more satisfactory results.

In fabricating the new fire box to replace the old one removed we find in laying out the sheets that form it, that numerous irregular shapes develop. Formerly the trimming of these sheets was performed under the power punch. They are now cut with the oxy-acetylene torch which reduces the cost and saves considerable time. We have partly welded fire boxes now in service and their performance so far is all that could be expected and I believe that by employing the long flange so that the weld is made between two rows of stay-bolts, almost perfect results can be obtained. The welding of these seams can be done with either the oxy-acetylene or electric arc process.

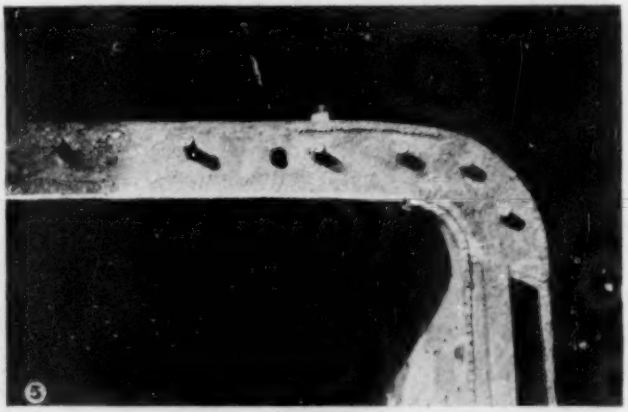

Fig. 5. Welding Mudring.

In removing the mudring from the boiler, we very often find the bottom of the ring in poor condition due to corrosion. The sharp corner of the mudring in many instances is eaten away. We build up the corners and all flat surfaces where corrosion has taken place. (See Fig. 5).

After the inside fire box is removed from the boiler the stay-bolts still remain in the outside wrapper sheet. To remove these bolts the oxy-acetylene torch is employed to burn the bolt half way through the sheet; the bolt is then hot enough in the sheet so that it can be worked out by a helper who uses a short length of pipe for this purpose. This method of removing stay-bolts from side sheets is fast and is an improvement over the old method of drilling them out.

We apply a great many flexible stay-bolts to locomotive boilers, the sleeves of which were formerly screwed into the outside wrapper sheet, which is rather an expensive operation. The new style sleeve is ball seated and welded to the wrapper sheet by the electric arc process. The oxy-acetylene torch could not be employed

on this class of work as on account of the diffused heat, the sleeve and sheet would have a tendency to warp. A particularly advantageous feature of the electric arc weld is afforded through the concentration of the intense heat in a small area enabling it to be applied just where it is needed without heating up much of the adjacent material.

In welding *fire door seams* the practice of some roads is to prepare the door hole seam as ordinarily done for plugs or rivets and then lap weld the flange to the back head. The method followed by the Southern Pacific Co., is to butt the flanges of the back head and door sheet, and weld with either the electric arc or oxy-acetylene process. We have been following this method for several years and have never experienced any trouble.

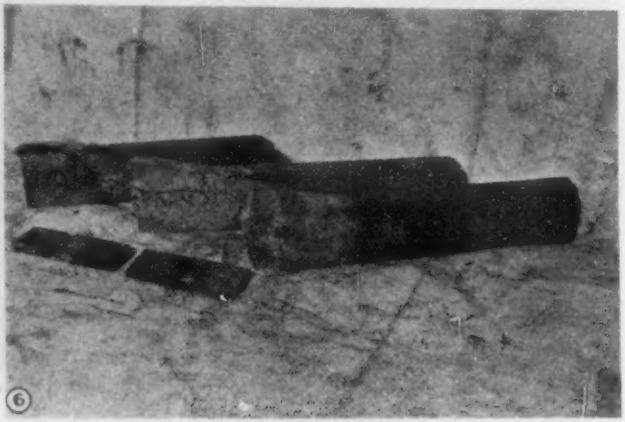

Fig. 6. High Speed Steel Cutting Points Electric Welded onto Lathe Tools.

There are many other articles repaired in the boiler shop by welding; among them is a bail for a drag-line bucket. This bail came in the boiler shop broken in several places. We applied a 1″ reinforcing plate on the bottom side and welded it all around on inside and outside edges with the electric arc, thus insuring a strong durable job which will stand up to the very heavy service imposed upon it.

MACHINE SHOPS.

We will now proceed to the machine shops; here we find many and varied articles that are repaired successfully by welding.

Among the many various parts repaired in this department are trailer truck equalizers, transmission bars, eccentric cranks, cross heads, coupler supports, truck frames, chafing iron castings, radius bars, truck spring hanger pins, eccentric blades, links, guide yokes, ends of axles, swing hangers for pony trucks, center castings, and sills for tender frames, cylinder head casings, injectors, piston rods, cylinder heads, superheater units, reverse

shafts, dope cups on rods, cylinders, piston heads, and axle collars.

In addition a wide field is found in boiler repairs, for example, we have the front flue sheet of a superheated locomotive; the steam pipe, dry pipe and header are all in good condition and in

Fig. 7. Worn Rim on Axle to be Filled in by Welding.

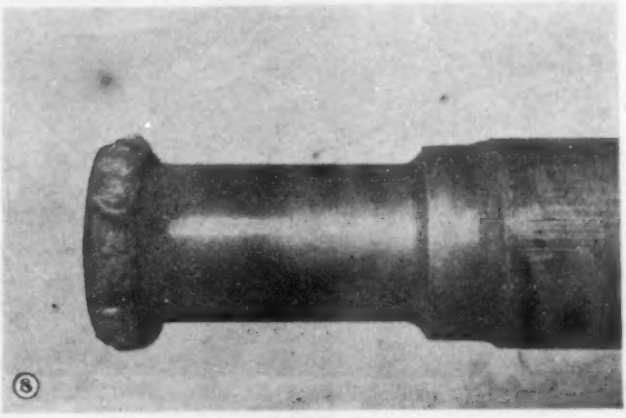

Fig. 8. Axle after Rim of Journal had been Welded

place. During the inspection of this boiler we find the bottom of the tube sheet badly corroded and cracked so much so that it is practically beyond repair. If the welding process was not available we would find it necessary to remove the entire sheet, which would cause considerable delay and add greatly to the cost of making repairs to this boiler. The repairs are made by cutting out the lower section of the sheet leaving the dry pipe and header in place and welding in a new section.

Defects that develop in the fire box sheets are repaired with both oxy-acetylene and electric arc processes by applying new half side or tube sheets. The defective parts are cut out with the oxy-

acetylene torch and the electric arc is employed almost exclusively in welding in the sheets.

Another operation in which the electric arc has been employed to great advantage in railroad shops is in the maintenance of boiler tubes. Tubes are applied in the boiler in the usual manner

Fig. 9. Break in Locomotive Frame Welded.

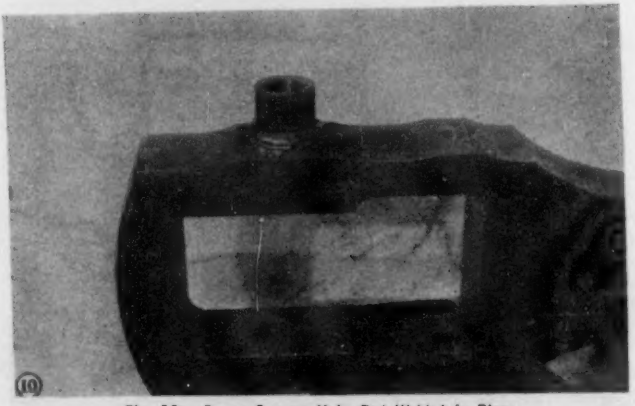

Fig. 10. Grease Cup on Main Rod Welded in Place.

and placed in service. After they have been in service a certain period or when they show signs of leaking the locomotive is held and the tubes are given a thorough working, then the sheets are roughened or sand blasted and the tubes welded to the sheet. We find this method has given excellent results.

STEEL FOUNDRY

In the steel foundry where many castings are manufactured every day, broken and defective castings can be reclaimed by welding those that are found defective from sand spots, blow holes or shrinkage cracks. These welds when properly made are as readily machined as any other part of the work. Risers and sink heads

can be cut off quickly and more cheaply than by any other method.

Fig. 6 shows method of welding high speed steel points on carbon steel lathe tools, which gives very good results and save making the whole tool out of expensive high speed steel.

Figures 7 and 8 show worn outer collar of car axle before and

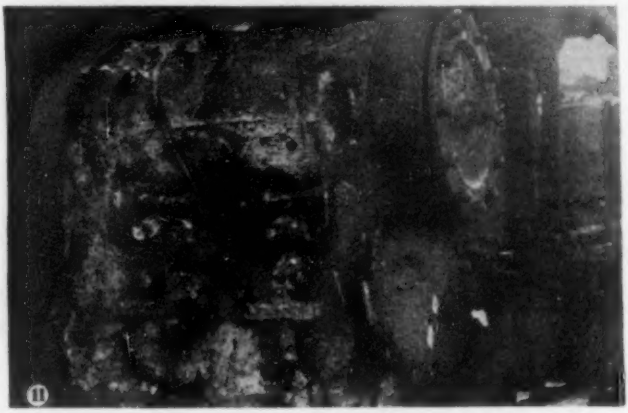

Fig. 11. Crack in Cylinder Welded.

after reclaiming with the electric welding process. By machining the collar to original thickness the axle is ready for use again; otherwise it would have to be scrapped.

Fig. 9 shows a locomotive frame that had broken and was welded with the electric arc. This is a very good illustration of the saving that can be made by using the oxy-acetylene or electric welding processes. Formerly with a break of this kind it was necessary to drop the wheels and do considerable stripping before frame could be welded with thermit, or other means. This weld was made with the arc without doing any stripping or disturbing the driving wheels. We have had very good success with welds made in this manner. The material is cut out with the oxy-acetylene cutting torch, trimmed up by hand and then electric welded.

Fig. 10 illustrates method of welding grease cups on locomotive rods. The cup is finished in a Turret Lathe and set over hole in rod, welded and then smoothed up with a hollow mill. After finishing they have the appearance of having been made integral with the rod.

Fig 11 shows an electric welding job on a cracked locomotive cylinder. The break is V'd out and studs applied in sides of crack and then filled up solidily with the arc.

Figs. 12 and 13 show the preparation, installation and welding of flexible stay-bolt sleeves on a locomotive boiler. After holes are drilled and countersunk to suit sleeves the surface sur-

rounding the holes is cleaned and roughened, which breaks away all scale and dirt on sheet and gives the welder a chance to do a much better job than would otherwise be possible.

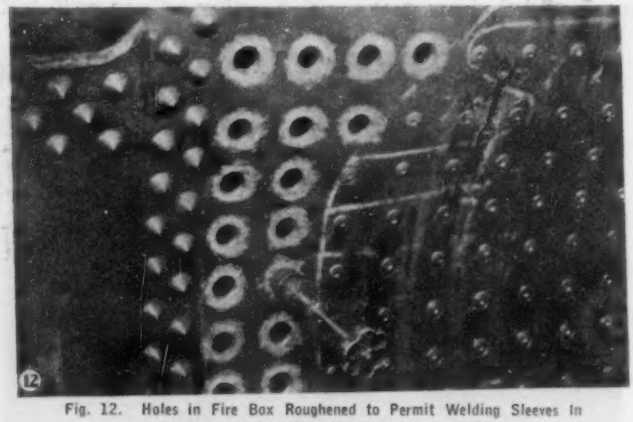

Fig. 12. Holes in Fire Box Roughened to Permit Welding Sleeves in Place. Method of Holding Sleeves while Welding.

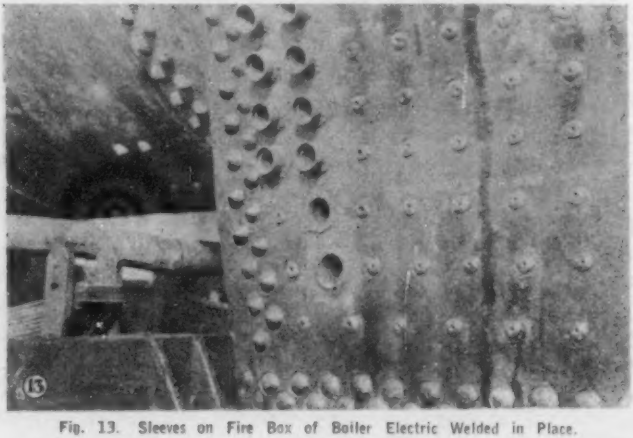

Fig. 13. Sleeves on Fire Box of Boiler Electric Welded in Place.

Fig. 14 shows welds across center of front flue sheet on 2-10-2 class locomotives, lower portion of sheet being new.

Fig. 15 shows method of applying patch to top of door sheet. The patch is necessary on account of lap cracks and sheet pitted in knuckle. This patch has been tack welded in several places in order that bolts and clamps may be removed. Fig. 16 shows the same door sheet after welding.

The scrap and reclamation dock is where many parts are reclaimed with oxy-acetylene welding, such as switch points, frogs,

couplers of all sizes and types, coupler knuckles all types, continuous rail joints, track drills, switch stands, oil cups, water strainers, spring plates, steam hose couplings, pipe cutters, monkey

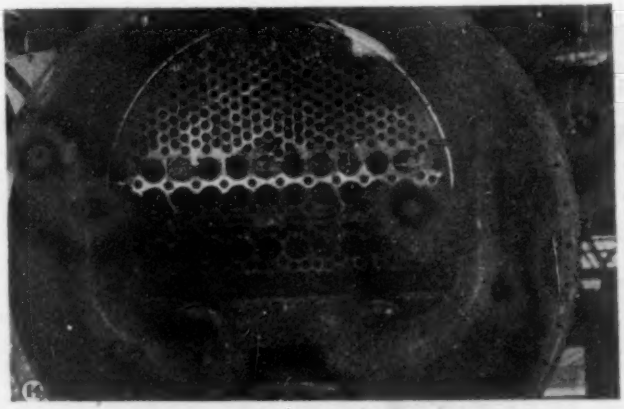

Fig. 14. New Section of Front Tube Sheet Welded in Place in Boiler

Fig. 15. Patch in Door Sheet of Locomotive Firebox Ready for Welding.

and stillson wrenches, oil drums, ballast forks, body bolsters, truck bolsters, journal boxes, track jacks, brake heads, etc.

The most successful applications of welding undoubtedly have been in places where thorough supervision and training of welders have been carried on. No matter what kind of material is to be welded, or what the type of welding is, the reliability of the weld rests in a large degree with the operator.

Careful examination and inspection of the welded joint is of the

utmost importance. There are certain factors which determine the physical characteristics of the weld.

First, examination of the weld by visual means.

Second, the edges of the deposited metal should be chipped with

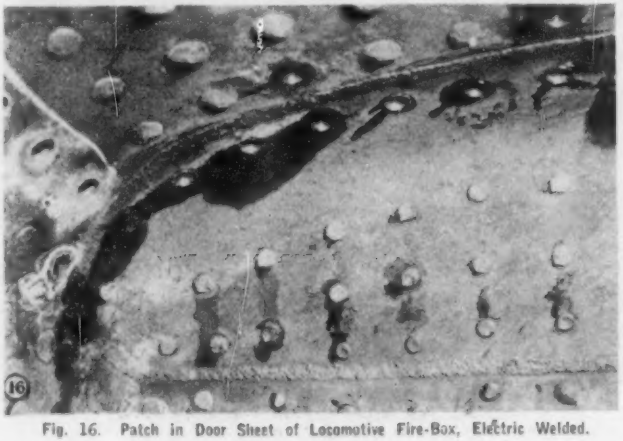

Fig. 16. Patch in Door Sheet of Locomotive Fire-Box, Electric Welded.

a cold chisel or tried with a calking tool to determine the relative adhesion of deposit.

Third, pulling apart welded sections cut from the finished product.

Fourth, the bending or breaking test.

In conclusion I will say that at the Sacramento General Shops, we have very efficient Welders and Cutters who are entirely dependable and who have the confidence and ability to turn out work that is durable and entirely satisfactory.

APPLICATIONS OF THE CUTTING OF CAST IRON WITH THE OXY-ACETYLENE TORCH†

BY A. S. KINSEY*

Many valuable applications of the oxy-acetylene torch to the cutting of cast iron have developed since it was found about two years ago ** that this metal could be satisfactorily cut by the flame. There had been some difficulty in obtaining practical results at first, due principally to improper design of torches and tips. As was shown, however, an intermediate pressure cutting torch would cut cast iron satisfactorily, with modifications required only in the tip. In fact a new tip just designed for such work will cut cast iron better than the writer has ever seen it done before.

Of course it was hardly to be expected that there would be as great need of the oxy-acetylene cutting torch for cast iron as there has been for low carbon steel, and any hesitancy to use the torch on cast iron would be but a repetition of the general attitude toward the oxy-acetylene torch when it first was offered as a means for cutting steel. No one now questions the value of the cutting torch on steel, and it will not be long before the cutting of cast iron by the same principle of oxidation will be just as readily accepted. The justification for this belief lies chiefly in the fact that although until within the past few weeks the so-called cutting of cast iron was probably a melting action, as much as one of oxidation, it is now possible to do the cutting as completely by oxidation as is true in the cutting of steel. We will refer to this again.

SOME TYPICAL EXAMPLES OF CUTTING CAST IRON

1. *Scrapping Locomotive Cylinders.* As would be expected the railroad locomotive shops were quick to see the advantages of cutting cast iron with the torch, especially when this could be done with but the slight additional expense of the cost of only a special tip. About the first job attempted therefore was the scrapping of obsolete and worn out locomotive clyinders. Fig 1 will be recognized as a tpyical picture of a locomotive cylinder scrap yard. At one time it was customary to break up these cylinders with the skull-cracker, a heavy cast iron ball hoisted 25 to 50 feet and allowed to fall upon the cylinders, but safety committees have prohibited this practice unless a high brick safety wall is built around the break pile to prevent flying pieces of the castings from injuring workmen. Most railroads have not had the available funds for this improvement, and as there was no other way to break up the cylinders they were stored in an out of way place. The cut-

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**Cutting Cast Iron with the Oxy-Acetylene Torch, by A. S. Kinsey, Meeting American Foundrymen's Association at Columbus, Ohio, October, 1920.

†Presented before Meeting Metropolitan Section, A. W. S., December, 1922.

ting torch is now being used to reduce these iron castings to charging-door size of scrap so that they may be melted in the cupola and added to the supply of good quality cast iron for the needs of the foundry. The cutting can be done in the scrap yard regard-

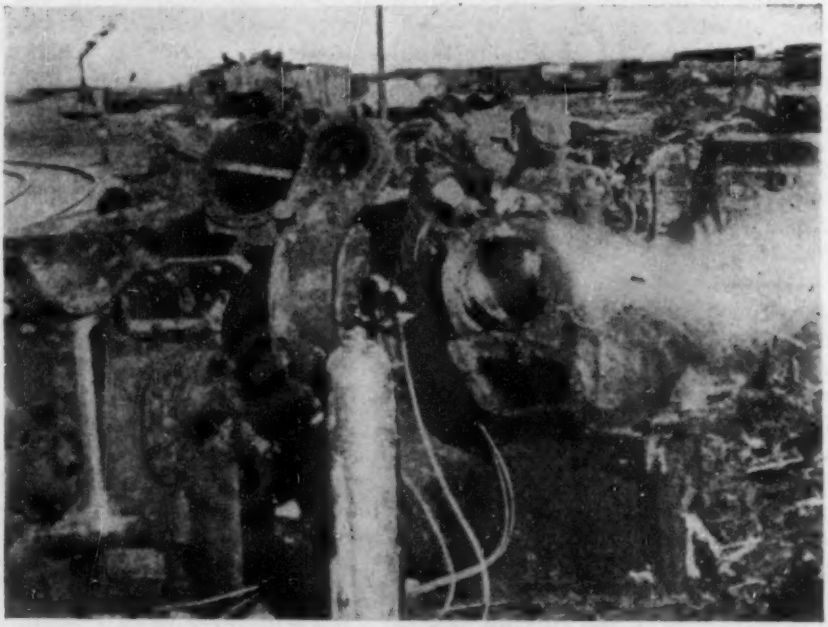


Fig. 1. Scrapping Locomotive Cylinders with Oxy-Acetylene Cutting Torch.

less of cold weather, and but little practice is required for a man to be able to do the work. It is true that the first cost of such cutting appears to be higher than that of the quick breaking of the casting with a skull cracker, but on the other hand careful analysis of the cost for power, labor and repairs of the skull- cracker outfit will show that it is no more economical that the torch cutting.

2. *Removing Cylinder Bushings.* One of the most serviceable pieces of cast iron cutting being done in the locomotive shop is that of removing bushings from the cylinder barrels and the valve chests. When a cylinder has worn too large in diameter the common practice is to reduce the inside diameter so that it again will fit the piston, by forcing into it a ring of cast iron, called a *Bushing,* the full length of the cylinder bore. After a time however, this bushing becomes worn too large and it must be removed to make room for a new bushing. Until recently this has been done by chipping it out with hammer and chisel. The oxy-acetylene torch is now used for this work, and can remove a main cylinder bushing in about 15 minutes as compared with about 3 hours with

chisel. The details are as follows:

With Torch		*With Chisel*
15 minutes		3 hours
Oxygen	$ .85	
Acetylene	.03	
Labor	.20	$2.40
Total	$1.08	$2.40

Two cuts the length of the bushing must be taken in both methods. The oxy-acetylene cutting can be done without injuring the cylinder walls. In the case of cutting out valve chest bushings with the torch, three equidistant lengthwise cuts should be made to avoid marring the ports and bridging.

There are other interesting examples of the cutting of cast iron in railroad shops, but let us look into a ship yard for a piece of heavy cast iron cutting.

3. *Scrapping Propellers.* In a ship yard a heavy broken cast iron propeller is much in the way. The hubs are often too thick

Fig. 2. Cutting Propeller Hub with Oxy-Acetylene Torch.

to break with a skull-breaker, sometimes they are buried, or dumped into a swamp, but in city shipyards they often remain in the way. This condition need not continue, however, as they can be cut up with the oxy-acetylene torch. Figure 2 shows a serviceman demonstrating what can be done on a propeller hub in an eastern

shipyard, which required two cuts each 20 inches long through thicknesses varying from 7 to 12 inches. The following data were obtained:

CUTTING HUB OF 5 TON PROPELLER

Oxygen	$14.00
Acetylene	6.00
Labor, 2 hours	1.56
Total	$21.56
Value of hub as scrap, about	$100..00

Additional advantage	Out of Way
Longth of 2 cuts	40 inches
Thickness of cut	7 to 12 inches
No preheating was required	

Figure 3 gives a good idea of the slot or kerf made by the torch, which was not as straight as it would have been on more important

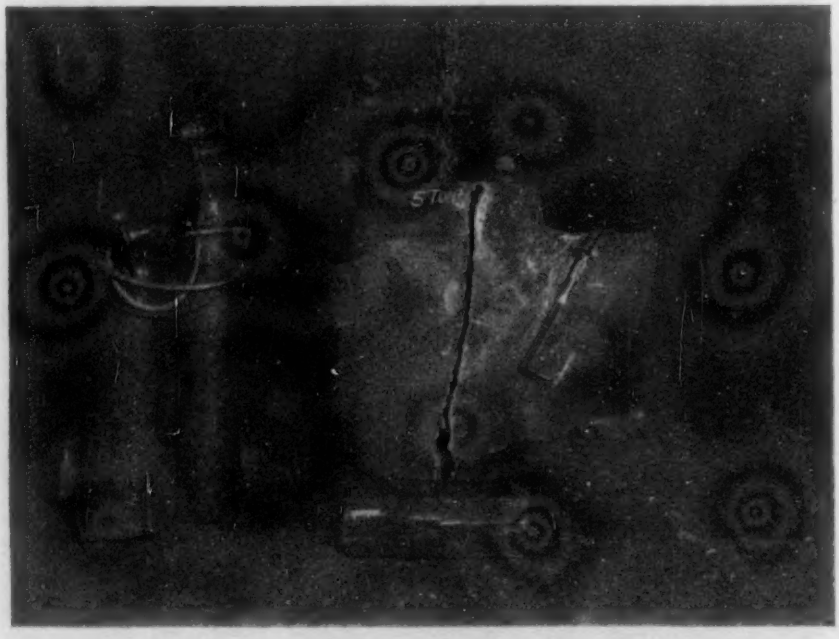


Fig. 3. Kerf Left by Cutting Torch in Cast Iron Propeller Hub.

cutting than scrap. Figure 4 shows the hub cut apart, from which may be appreciated the ruggedness of the cutting.

4. *Removing Gates and Risers.* Ordinary gates and risers of iron castings are usually broken off by a blow of a hammer, which is the most economical way. There are times however, when big gates and risers have been improperly molded, or they may have

broken wild and a jagged projection is left to be removed. The torch will serve very efficiently in these cases, and the cutting may be done close up to the casting without affecting the carbon balance of the iron and hardening the surface.

5. *Repairing Cast Iron Vessels.* The cast iron tanks used in chemical plants sometimes requires a new bottom put in them.

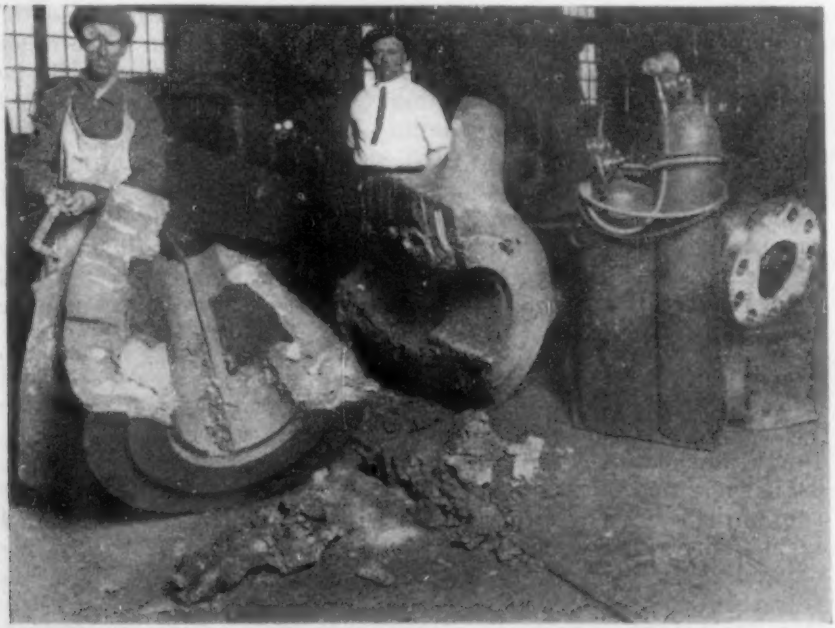


Fig. 4. Character of Cut Through Cast Iron Propeller Hub.

The old bottom can easily be cut out with the oxy-acetylene torch. The big cast iron bowl-shaped vessels used in non-ferrous metal foundries, die and chemical plants and other places, wear out and must be removed and scrapped. Some of these vessels are 12 to 15 feet in diameter and are difficult to get out of the building. They can be cut up in position with the torch, small enough to be sent to the cupola for remelting.

6. *Altering Machine Bases.* Sometimes it is desired to shorten the cast iron base of a big machine, or such a base is located in a sub-basement and must be scrapped, or the cast iron bed plate of an engine needs to be altered, or an opening must be made in some such casting down in a crowded engine or machine room. The oxy-acetylene torch is proving invaluable for this sort of work, often avoiding serious delay to a power and lighting plant.

7. *Cutting Cast Iron Pipe.* Until recently the cutting of cast iron pipe with the oxy-acetylene torch could not be done as cheaply as by dimond-pointing, that is, cut by hammer and a chisel having

a dimond-shaped end. It requires a "big fire" to cut cast iron by torch and the walls of cast iron pipe are so thin the heat from the oxy-acetylene flame goes through the metal so quickly that the burning, or cutting, progresses rather slowly. A new design of torch tip, however, has overcome this trouble, and the cutting of cast iron pipe with the torch will undoubtedly soon become common practice on water, gas, drainage and other uses of such pipe.

8. *Beveling for Welds.* One of the most serviceable uses of the cutting torch is for beveling the edges of cast iron to be welded. The oxide scale left on the bevel by the torch may easily be shattered loose with a hammer, and the metal has not been injured by the action of the cutting torch.

9. *A Demonstration.* An indication of the interest shown in the cutting of cast iron may be seen in Figure 5, which is a view of some of the men who formed an audience of about 400 at a lecture on cutting cast iron by the writer given in the Carnegie Institute of Technology, Pittsburgh, Pa. The demonstration was conducted after the lecture late in the evening in the foundry of the Carnegie Shops.

ECONOMY OF CAST IRON CUTTING

Recent figures show that the cost of cutting thick cast iron with the oxy-acetylene torch is about four times that of cutting steel, the thicker metals being more economically cut than the thin ones.

In some of the latest cutting of cast iron a rate of about 10 square inches per minute was made in a cut 13 inches deep by 14 inches long. This would cost say 1 cent for labor, 12 cents for oxygen, and 3.5 cents for acetylene, making a total of 15.5 cents to cut 10 square inches per minute.

Steel 12 inches thick can be cut at a rate of about 30 square inches per minute, which would cost 1 cent for labor, 9 cents for oxygen and 1.5 cents for acetylene, a total of 11.5 cents to cut 30 square inches per minute.

To make these figures comparable with other cutting data we will compute them for cutting 100 square inches:

OXY-ACETYLENE CUTTING OF
100 SQUARE INCHES OF CAST IRON AND STEEL
BY HAND TORCH.

	CONSUMPTION			*COST*			
Material	Time Min.	Oxygen c. f.	Acetylene c. f.	Labor	Oxygen	Acetylene	Total
Steel	3.33	25	2	$ .04	$ .30	$ .05	$ .39
Cast iron	10	100	15	.10	1.20	.35	1.65

Of course this comparison should not end with the above figures for if it were not possible to cut cast iron with an oxy-acetylene torch it would have to be done by machinery. This would cost to cut off a section of 100 square inches about $5.00 which makes the

machining cost about three times as much as the torch cutting.

To summarize:

COMPARATIVE COST OF CUTTING 100 SQUARE INCHES OF METAL.

Metal	Cut by	Cost per 100 sq. ins.
Steel	Oxy-Acetylene Torch	$ .39
Cast Iron	Oxy-Acetylene Torch	1.65
Cast Iron	Machinery	5.00

HOW TO CUT CAST IRON.

1. Use a special tip in a regular torch for cutting steel if it is of the medium pressure type.

2. Use the size of tip and the oxygen and acetylene pressures given in the table below.

3. The flame should be about 2 inches long and be made carbonizing with an excess of acetylene.

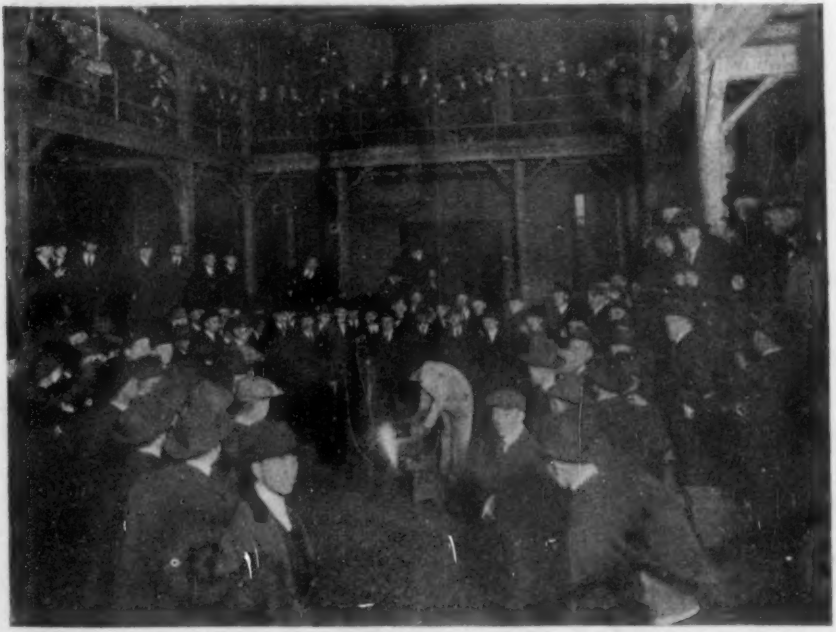


Fig. 5. Cast Iron Cutting Demonstration in Foundry of Carnegie Institute of Technology.

4. Warm the casting near the cut for a few seconds with the Oxy-acetylene torch.

5. Start the cut at the bottom, directing the flame toward the cutter, and slanting the tip forward so that the flame strikes the bottom corner of the casting at an angle of about 45 degrees. Then after the cut gets well started gradually pull the torch toward

the casting so that the cutting angle will change to a vertical position. As soon as the cut has penetrated the full thickness of the casting the tip should be slanted about 45 degrees, which will cause the sparks to be thrown away from the cutter. This will make the actual depth of cut about 18 inches, which can be accomplished quite satisfactorily.

6. If the cut is deep a helper should stand at the cylinders to keep up the oxygen and acetylene pressures.

7. The cut should be made by spiraling the tip, that is instead of holding the torch steadily, as in the cutting of steel, give it a spiral motion so as to widen the cutting groove, called the *Kerf*, allowing the flame free access to the metal, and get the slag out of the way quickly. Or the tip can be slightly swung from side to side to widen the kerf.

8. The cutting should be done at a speed which will leave no slag bridges across the kerf. The pieces should freely drop apart at the end of the cut.

9. As soon as the cut is made, cover the hot ends with asbestos, or dry sand, and do not knock off the slag scale until the metal is quite cold. These precautions will keep the cast iron soft and machinable. If the ends are not to be machined then they do not need to be covered, and the scale may be knocked loose while still hot. The metallurgy of this will be given in a later chapter.

10 The cutter should take extra precautions to protect himself against the unusual heat.

TIPS AND PRESSURES FOR CUTTING CAST IRON
AIRCO-DAVIS-BOURNONVILLE CUTTING TORCH

Number of Tip	Thickness of Metal	Oxygen Pressure, lb.	Acetylene Pressure lb.
1	½"	20	4½
1	¾	30	4½
2	1	30	5
2	1½	35	5
2	2	45	5
3	3	55	7
3	5	75	7
4	7	95	9
4	9	125	9
5	10	130	10
5	15	150	10

EFFECTS OF OXY-ACETYLENE CUTTING ON CAST IRON.

Much heat and smoke is produced in the cutting of cast iron as compared with the cutting of steel, (see Figs. 2 and 6).

The kerf must be made three or four times wider than that for steel, which requires the burning of a larger amount of the pure iron, called *Ferrite*.

A liberal amount of slag scale is left on both cut surfaces of cast iron, which is a fortunate condition, as it prevents the iron from becoming too hard to machine.

The fact that the heated surfaces are but little harder after than before the cutting is done indicates that there has been but slight change in the carbon of the cast iron. Undoubtedly the oxide scale left by the cutting action serves as an insulator of the hot metal from the cold air, and allows it to cool slowly enough to cause the proper proportion of combined carbon to change back to graphitic carbon. This transformation of carbon may be explained as follows: Ordinary iron castings contain carbon in two forms, that which will not combine with the pure iron (*ferrite*), called *Uncombined* or *Graphitic Carbon*, and that which will combine with the ferrite, called *Combined Carbon*. Graphitic carbon softens and weakens cast iron, while combined carbon hardens and strengthens it. The amounts of these two carbons in cast iron vary according to the grade of pig iron from which cast iron is made, as may be seen by the following table, which also shows the other common chemical elements in the metal:

GRADES OF CAST IRON

	No. 1 Iron	No. 2 Iron	No. 3 Iron	No. 4 Iron	No. 5 Iron
Carbon (Graphitic)	3.50%	3.00%	2.50%	2.00%	.20%
Carbon (Combined)	.15%	.40%	1.50%	2.00%	3.80%
Silicon	2.40%	2.50%	.70%	.60%	.40%
Manganese	.30%	.70%	.30%	.70%	1.00%
Phosphorus	1.25%	1.00%	.25%	.20%	.04%
Sulphur	.02%	.02%	.01%	.08%	.02%
	7.62%	7.62%	5.26%	5.58%	5.46%
Ferrite	92.38%	92.38%	94.74%	94.42%	94.54%
Total	100.00%	100.00%	100.00%	100.00%	100.00%
Color of Fracture	Dark Gray	Medium Gray	Light Gray	Mottled	White

Now when cast iron is melted practically all of the carbon combines with the ferrite and not any is left in the graphitic condition. If the iron is then allowed to cool quickly all of the carbon will remain in the combined state and the metal will be too hard to machine. If however, the cast iron is made to cool very slowly from the molten liquid condition back to the cold solid casting, enough of the carbon will be released from the ferrite and become graphitic carbon to again equal about the original proportion of the two carbons, and the casting will be soft and machineable.

Therefore when cast iron is cut with the oxy-acetylene torch the surfaces adjacent to the kerf are melted or heated high enough to throw all the carbon in the combined state and if the casting were allowed to cool quickly the cut surfaces would be too hard to machine. This is prevented however by the heavy oxide scale which is formed from the cutting of the metal and which completely covers the two surfaces, thus insulating the hot metal from the cold air and causing a slow cooling, (Figs. 7 and 8). In the cut-

ting of some cast iron the scale may not be thick enough to produce sufficient final softness, in which case it would be well to cover the cut ends with asbestos paper. Of course the oxide scale should not be disturbed until the casting is cold to the hand, when the scale may easily be shattered loose by a hammer blow.

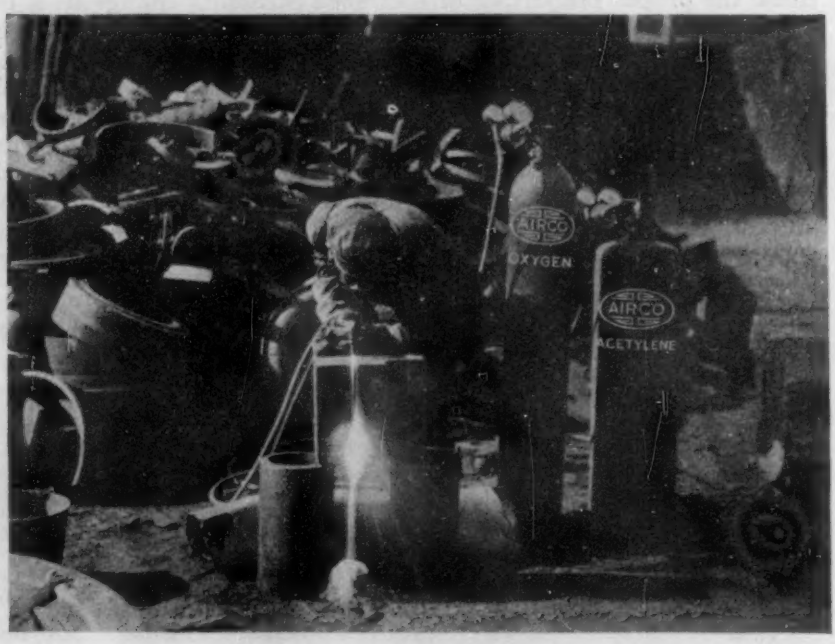


Fig. 6. Cutting 13 inch Steel with Very little Smoke.

THEORY OF THE CUTTING OF METALS WITH GAS

Previous to about two years ago, it was generally believed that cast iron could not be cut with the oxy-acetylene torch. At that time, however, some interesting experiments proved that cast iron could be cut, and it was concluded that the cutting was accomplished by a combination of oxidation and melting. While the deposit from the cutting was largely oxide ash, there was also a liberal amount of molten iron in it. It was therefore concluded that complete oxidation or burning of the metal, similar to that accomplished in the cutting of steel, was impossible, although the metal could be satisfactorily cut with the oxy-acetylene torch.

It will be of interest therefore to state that recent experiments in the cutting of heavy cast iron, including the cutting done under the supervision of the writer at the presentation of this paper to the December 1922 Meeting of the American Welding Society, Metropolitan Section, held in New York City, was accomplished with as perfect oxidation of the metal as is usual in the cutting of steel. That is, there is now good reason for believing that cast

iron can be oxidized just as completely as steel if the proper design of torch and tip are used.

The cutting last referred to was about 13 inches deep by 14 inches long, although when the cut was properly started and the cutting angle of 45 degrees was gotten, the depth of the cut was about 18 inches. The casting had been taken at random in a scrap yard, and its chemical composition was not known. The oxide deposit from the cutting was free of molten iron and could easily be

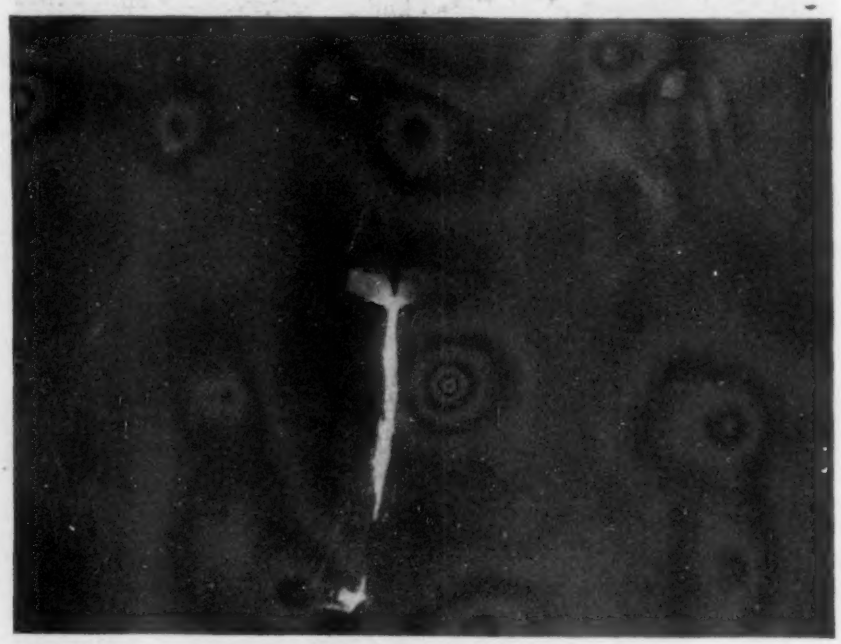


Fig. 7. Stream of Slag in Cutting Cast Iron.

crushed between the fingers. The kerf surfaces showed the best cutting of cast iron the writer has seen. The cutting was done with our latest model cutting torch for steel, fitted with a new design of tip for cutting cast iron.

It is evident therefore that the only reason cast iron has not been cut by complete oxidation heretofore is because the tip was not properly designed to accomplish the work.

From the very first cutting of cast iron it was found that the best flame was a carbonizing one using a liberal excess of acetylene, and the new tip is designed to take advantage of this.

In the light of the latest results of the cutting of cast iron it may be of interest to compare the oxidizing conditions of that metal with steel. In the cutting of steel a spot is made red hot (this temperature has been determined to be about 1800 degrees fahr. for wrought iron and low carbon steel) with the preheating

flame, and then the high pressure oxygen of the torch is snapped on. This starts cutting action and a groove is burned or oxidized through the metal.

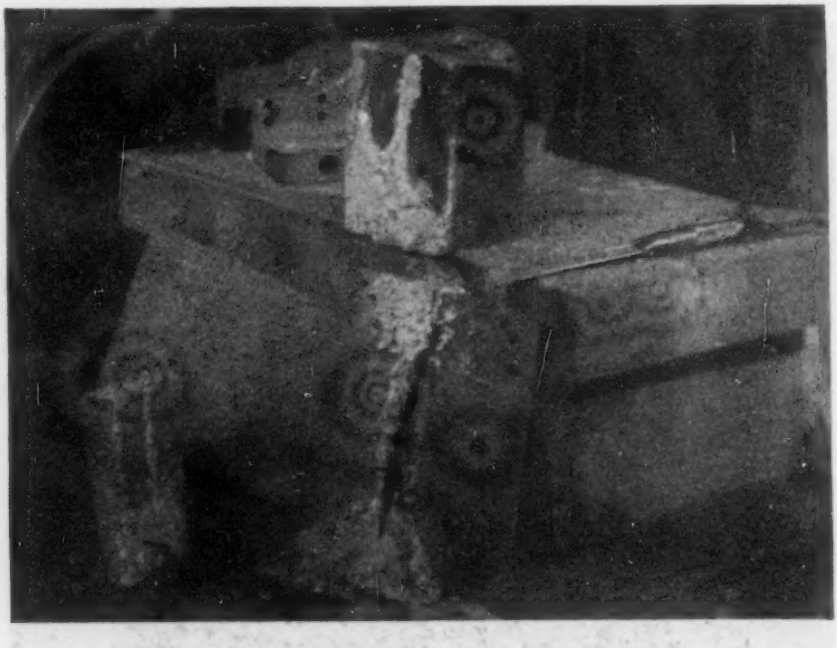


Fig. 8. Slagged Surfaces of Cast Iron Cut.

Now it is well known that the less the amount of chemical impurities in the metal the easier it may be cut. So that wrought iron containing only about 0.25% impurities would cut more readily than steel containing about 0.85% impurities, while cast iron with about 7.0% of chemical impurities would be the hardest of all to cut. The chemical impurities in all these metals are carbon, silicon, manganese, phosphorus and sulphur. It is quite probable that carbon is the particular chemical element which affects the cutting. Wrought iron contains only about .02% of it, low carbon steel about .20% and cast iron about 3.50% carbon.

The carbon in cast iron is in two forms, one that lies between the flat-sided grains of the metal and is not part of them, which is called *Uncombined* or *Graphitic Carbon*, and another form which is absorbed by the grains of metal and known as *Combined Carbon*. The proportions of these carbons varies according to the kind of cast iron, as shown in the table on page 29.

Now it is generally thought that the graphitic carbon lying in flake form between the grains of cast iron tends to interfere with the burning of the iron and thus retards the cutting action of the oxy-acetylene torch. There is also the possibility of the compar-

ative large amount of combined carbon in the pure iron making it difficult to burn the iron. Again it may be that the high proportion of 2.50% of silicon in cast iron to only about 0.05% in steel may have a deterrent effect on the cutting.

Whatever may have been the cause of the difficulty heretofore, one thing is now certain, cast iron can be completely oxidized by the oxy-acetylene torch even in thicknesses up to 18 inches.

ARC WELDING

Some Incomplete Development Activities

O. H. ESCHHOLZ*

During a recent review of arc welding activities, the writer was impressed by the opportunity for still further developing the fundamentals of the science. A brief discussion of their status therefore appears desirable.

100% FUSION WELDS

One of the chief aims of welding development is to produce welded joints having physical properties comparable with those of the base metal. This goal has been achieved in some measure by the arc welded lap joint. Providing a high welding current is employed, to insure adequate penetration of both surfaces in combination with a weaving movement of the electrode terminal, complete fusion between the two members will be secured. With both sides of the lap united in this manner, failure under tensile stress, should occur consistently only in the base metal.

To obtain a 100% butt joint in mild carbon steel, it is necessary to employ either a heavy welt, special electrodes, or subject the deposited metal to mechanical work and heat treatment. If the filling metal in a weld has an analysis approximating the base metal, the unit rupturing strength will be slightly less than that of the base metal, owing to the fact that the latter has been given a rolling treatment. By increasing the thickness of the filling metal , this difference may be eliminated for some steels, although the margin of allowance for the variations encountered in practice is necessarily small.

Recent experience with alloy steel electrodes has resulted in the occasional production of machined welds stronger than the plate. This was found particularly to be the case on welding mild carbon hot rolled open hearth plate with 3½% nickel steel rods. In Figure 1 is shown a weld of this type. Before subjecting the weld to tensile test, the welts on both sides were ground off so that the cross-sectional area at the joint was approximately 95%

*Materials and Process Engineering Department, W. E. & M. Co.

that of the base metal. It will be noted that the fracture occurred 2½ inches from the weld. The ultimate tensile strength at the fractured zone was 51,000 lbs. per square inch. From the appearance of the joint after the test, the weld was estimated to have been at least 10% stronger than the base metal. With the employment of the usual welt a generous margin would have been obtained over the base metal. Although the future of the alloy steel weld is promising, the commercial use of alloy steel electrodes will not be advisable until the cause of wide variations between different welds, made apparently under the same conditions, has been identified and proper remedial measures adopted.

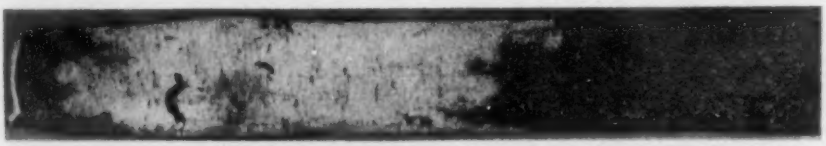


Fig. 1.
100 per cent Unforged arc weld; base metal, mild carbon open hearth plate; filling metal, nickel steel electrodes.

Forging* of butt joints has been shown to improve the properties of the filling metal. Of seven welds in mild carbon hot rolled steel bars, ½ inch x 2 inches that had been forged and either machined or ground flush with the base metal, six failed outside of the weld, the seventh failing within the weld owing to an unusually large oxide inclusion. With the usual welts all of these joints would have been considerably stronger than the base metal. While forging of all arc welded material may not be practicable, the breadth of the field for joints susceptible to mechanical working, may be indicated by the scope of the automatic hammer- gas welding process.

MECHANICAL WORKING

Arc deposited metal is obviously a casting with many of the characteristics of cast steel. But like all cast metal it is subject to improvement by processes of mechanical working and heat treatment. In discussing the properties of arc metal unfavorable comparisons are frequently drawn with the usual rolled base metal, the fact that the latter has had the advantage of a succession of either mechanical or heat treatments being conveniently ignored. As the arc metal, however, is also amenable to improvement by such treatments, it is only just that investigators should determine the margin of improvement possible. An illustration of the change produced in a mediocre quality of deposited metal by forging is given in Figure 2. It is of importance to note that the kneading action of the forging operation may actually produce a better metal in the weld, from the point of view of resistance to fatigue stresses, than the rolled plate as is indicated by the following table:

*Forging of Arc Deposited Metal and Arc Welds. O. H. Eschholz, Welding Engineer, August, 1921.

Material	Avg. No. of Cycles	Per Cent
Open Hearth Plate	26,175	100
Cast Arc Metal	8,611	33
Arc Metal forged at 1172°	44,781	171

It is felt that when the merits of forged arc metal are more widely recognized, a study will be made of the effects of various degrees of mechanical working with the resultant evolution of forging systems and procedures applicable to most welds.

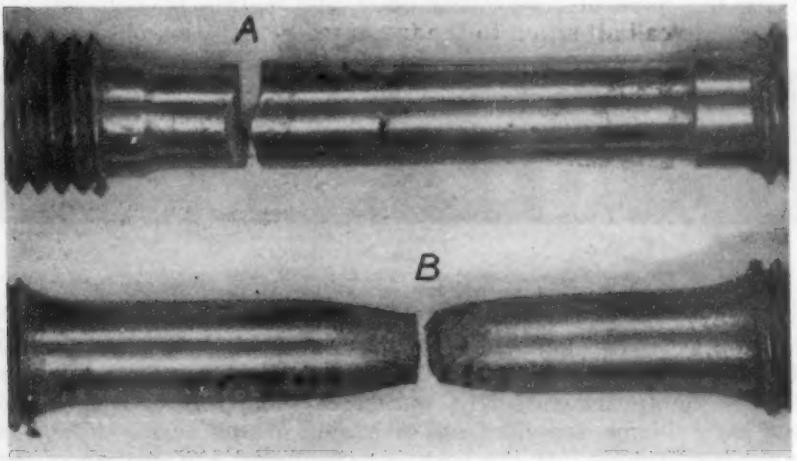


Fig. 2.
Improvement in Arc Metal secured by Forging.

(A) Unforged mediocre cast metal, square fracture, U. T. S., 43,500 lbs. per square inch. Reduction in area, 7 per cent.

(B) Forged metal from same block as exhibit A., full cup fracture, U. T. S. 57,175. Reduction in area, 60.1 per cent.

Heat treating has been employed, to date, chiefly for preheating or annealing purposes. With the use of filling electrodes that deposit metal susceptible to improvement to such treatments as nickel and other alloy steels, the field of arc welding will be considerably extended. Recent development * has shown that by combining mechanical and heat treatments alloy steel welds may be produced having physical properties comparable to those of the base metal. An illustration of this is the welding of chrome vanadium tool steel bars with nickel steel electrodes. The completed weld was forged on an air hammer, annealed from 900°C to room temperature, then quenched at 875°C in oil and finally drawn at 250°C, to relieve internal stresses. The weld and shank metal was machined and surface ground to uniform thickness and width, and subjected to tensile test, failing at an U. T. S. of 132,445 lbs. per square inch with an elongation across the fracture

*Forging of Arc Deposited Metal and Arc Welds. O. H. Ecchholz, Welding Engineer, August, 1921.

in 1 inch of 8.5% and a reduction in area of 5.6%. This weld is shown in Fig. 3.

ARC PHENOMENA—PENETRATION.

The characteristics of arc stability and the mechanism of metal deposition have been quite thoroughly discussed in arc welding literature. However, the phenomena of penetration of the anode arc terminal into the base metal has been given little study. Various observers have noted that the depth of penetration and contour of crater surface varies greatly with different electrodes, and that a magnetic field suitably disposed will cause further change. With the hope of interesting observers in this phenomena, it is desired to call attention to the increased penetration obtained with

Fig. 3.
Forged and heat treated chrome-vanadium steel weld, bare nickel steel deposition electrode. U. T. S. of machined joint 132,445 lbs. per square inch. Reduction in area, 5.6 per cent.

coated electrodes, particularly with coated nickel steel electrodes. The penetration depth is so great that it has been found possible to weld quite satisfactorily, *unscarfed*, abutting ⅜ inch plates, one layer being deposited on each side of the seam, the second layer penetrating into the first. Development and control of penetration phenomena would lead to:

1. The development of a cutting electrode.
2. Welding of butt joints with a minimum of preliminary scarfing.
3. Possible reduction of over-head welding.

A striking and unique illustration of high penetration is shown in Figure 4, where a layer of metal is observable on the bottom as well as on the top surface of the plate. This was produced by drawing an arc from the upper surface with a coated nickel steel electrode, 150 amperes, in such a manner that the positive crater liquified the plate metal, causing it to flow and come to rest on a mold ⅛ inch below the underside of the plate, the cavity formed by the displaced metal being filled in by deposited metal from the pencil electrode. An interesting application of this is shown in the tube, Figure 5, the reinforced section may be useful for a great variety of purposes. It is conceivable that electrodes may be developed having a still greater penetrative power, so that it will then be possible to join two over-lapping plates by welding through the upper into the lower as shown in Figure 6, thereby eliminating to some extent over-head welding. It is obvious that fusion ir

this type of weld would be facilitated by preheating the under plate with either a gas flame or carbon arc.

HIGH SPEED WELDING

Welding speed is fundamentally dependant upon the rate of metal deposition. This rate varies with such factors as, energy required for liquifaction of electrode material, arc stability, current density and electrical resistance of electrode material. To secure a working basis for estimating the maximum possible welding speeds, the metal deposited from bare mild carbon steel electrodes, on holding a short arc, was determined, with the following results:

RATE OF METAL DEPOSITION.

Elec. Dia.	Amps.	Lbs. of Elec. consumed per hr.	Lbs. of Metal Dep. per hr.*	Current Density***
5-32 in.	105	2.21	2.06	5400
5-32 in.	145	2.94	2.70**	7500
5-32 in.	180	3.7	3.44	9280
5-32 in.	235	5.25	4.1	12100
3-16 in.	230	5.25	4.8	8200
1-4 in.	375	11.2		7600

*Includes approximately 5 per cent of oxide.
**On holding a ¼ inch arc this was reduced to 2.1 lbs. per hour.
***Amperes per square inch.

On examining this data it will be observed that the deposition rate increases somewhat more rapidly than the increase in current value, presumably due to a proportional decrease in radiating surface per unit volume of arc stream and electrode terminal. To utilize commercially the advantage of high speed deposition obtainable with high currents, it is necessary to:

1. Maintain a quiet, stable arc.
2. Design welding joints that they will have a high thermal capacity and conductivity.
3. Develop a high penetration electrode for butt joint welding.
4. Determine the fillet depth necessary in lap welds to secure 100% welds.

With the ordinary bare electrodes, a violent, sputtering, arc throwing hot metal in all directions is a common occurrence at arc current values exceeding 300 amperes. The attendant disturbances render arc control both difficult and uncomfortable. By applying a thin coating of lime as an adherent film, a quiet stable arc will be secured, permitting welding with currents up to 500 amperes.

To secure a high thermal capacity in the butt joint, it is neccessary to reduce or omit the scarfing operation, the greater penetration obtainable with a high current arc assuring satisfactory fusion. The data in the following table was obtained on ½ inch thick open hearth plate. The joint welded with 175 amperes was the usual 90 degree double Vee type with abutting plates separated 1-16 inch. The plates welded with 400 amperes were not scarfed, but their abutting faces were separated by 3-16 inch nickel steel rods tack welded to the center line of one of the plate edges. This

separating rod served to prevent convection currents from destabilizing the arc as well as serving to introduce nickel into the fused joint.

MAX. WELDING SPEED FOR ½ in. PLATE (BUTT JOINTS).

Amps.	Elec. Dia	Welding Time Min.	Ft. per hour	Lbs. Elec. consumed per hr.	Lbs. Elec consumed per ft. of Weld
175	5-32 in.	22.6	5.3	3.46	.65
400	1-4 in.	11.6	10.3	12.0*	1.16
400	1-4 in.	11.0	10.9	12.0*	1.10

*Based on deposition rate in previous table.

It will be noted from this that despite the greater amount of metal deposited, high current welding resulted in an increase of

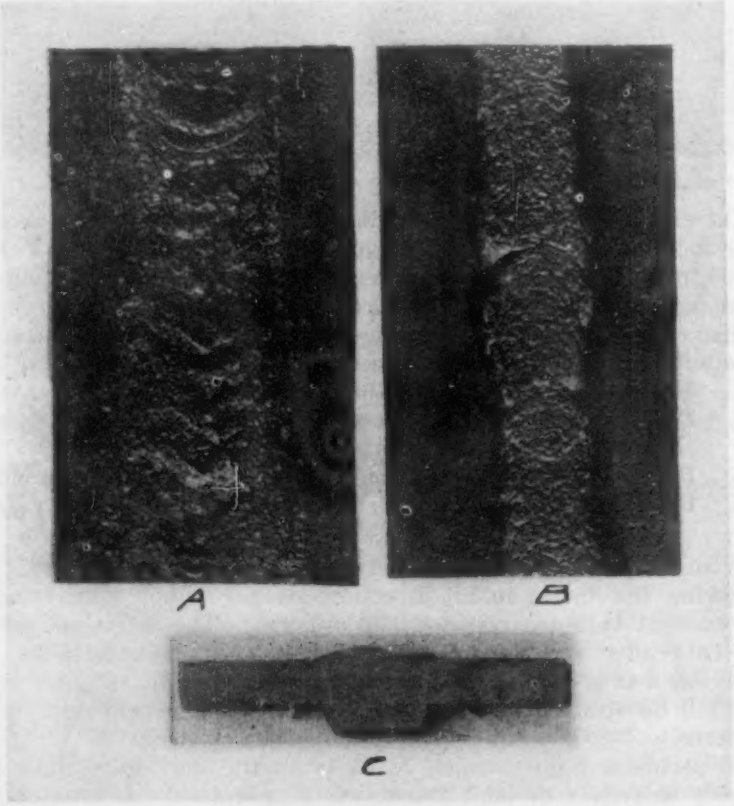


Fig. 4.

Formation of a protruding metal layer on the under surface of a plate by displacing the base metal when employing a "penetration" electrode.

(a) Top view of deposited metal.
(b) View of lower surface of protruded plate.
(c) Section through plate illustrating fusion between base, deposited and protruded metals.

100% in the speed of welding a butt joint. It is conceivable that with the further development of high penetration electrodes, it

would be possible to decrease plate separation and thereby further increase the speed obtainable with high currents.

The lap joint possesses inherently the requisite high thermal capacity and therefore permits a high energy concentration with the attendant high rates of fusion and deposition. In the following table are given the results of lap welding ½ inch thick open hearth plates with different currents:

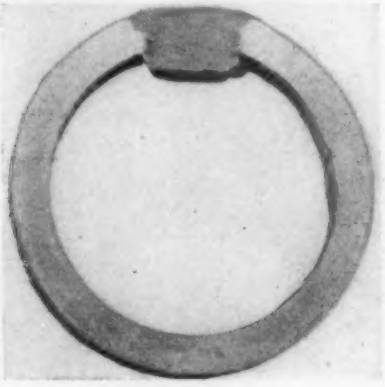


Fig. 5.
Section through a seamless tube with a protruberant layer formed on the inner surface.

MAX. WELDING SPEED FOR ½ in. PLATE (LAP JOINTS).

Amps.	Elec. Dia.	Time 4 ft. seam.	Ft. per hr. of Single Fillet.		Lbs. of Elec consumed per hour.	Lbs. of Elec. per ft. of Fillet.
175	5-32	26 min.	9.	8.8*	3.5	0.39
225	3-16	32.2 min.	7.45	13.6*	5.45	0.73
225	3-16	27. min.	8.9	14.5*	5.82	0.65
250	3-16	10. min.	24.	12. *	4.9	0.20
300	1-4	29.5 min.	8.15	18.5*	7.4	0.91
300	1-4	23. min.	10.45	19.2*	7.7	0.68
400	1-4	12.6 min.	19.	31.0*	12.5	0.65
400	1-4	8.7 min.	28.	31.0*	12.3 **	0.43

*Based on weight per foot run of fillet of 0.4 pounds.
**Coated electrode.

It will be observed that welding speed of lap joints is dependent upon two variables, deposition rate and weight of fillet. A weight of 0.4 lbs. per foot for ½ inch lap welds should give 100% weld strength, the lower limit of this weight has not been determined. The higher figure obtained for the first test when using 400 amperes is a result of the difficulty in controlling a high current arc when using bare electrodes. Two sets of welding speed data are given under the heading "feet per hour of single fillet." The first records the actual welding speed for the fillet weights given in the column at the extreme right of the table, the second gives the calculated speeds based on the recorded electrode consumption rate and a fillet weight of 0.4 pound per foot length

It is clear from this data that butt joints in ½ inch plate may be welded at a maximum rate of 5.3 feet per hour when employing 175 amperes; at 10.03 feet (or more) per hour when using 400 amperes and that ½ inch lap joints may be welded at a speed of 4.5 feet per hour with 175 amperes and 14 feet per hour with coated electrodes and 400 amperes.

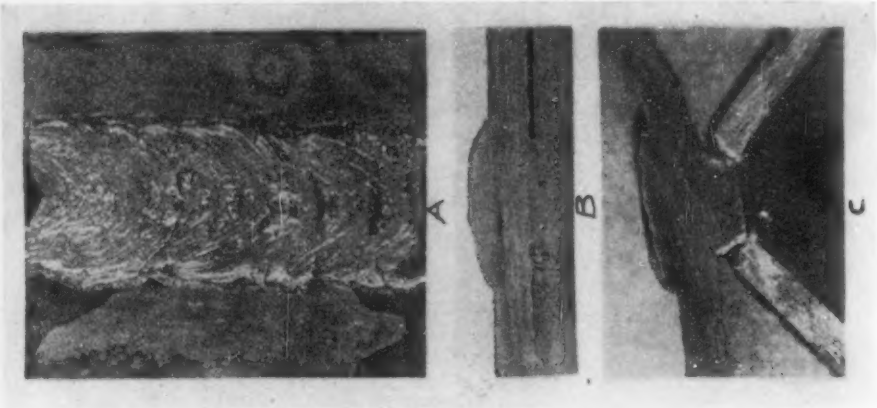


Fig. 6.
Application of the "penetration" electrode to the welding of overlaping 3-16 inch plate.
(a) Top view of deposited metal.
(b) Section through welded zone showing fusion between both plates.
(c) Character of fracture under bending load.

In addition to these activities, there are numerous others of a similar type relating to sources of welding energy, accessories, test methods, ferrous and non-ferrous electrodes, deposition procedure, etc., that present a rich field for the investigator wherein development achievements may be readily applied to commercial production.

PRODUCTION WELDING IN THE SHEET METAL SHOP

J. W. OWENS*

The gas flame holds a prominent place in the welding of thin sheet metal, both ferrous and non-ferrous. The reason for this is that the flame is "soft" and not extremely localized as is the case in the metal arc. The carbon and metal arcs have their place for they are being increasingly used every day, but it is doubtful if the gas flame will ever be entirely replaced by either of these forms. Of course, in production welding the aim should be the use of a multiple flame machine driven torch, but its installation is not always justifiable in view of the variety of forms and shapes of the work undertaken.

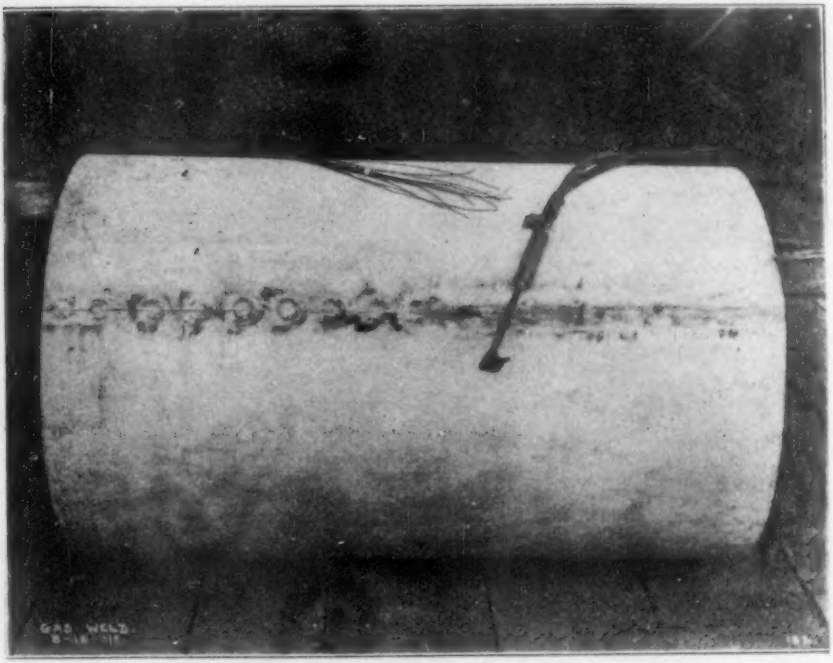
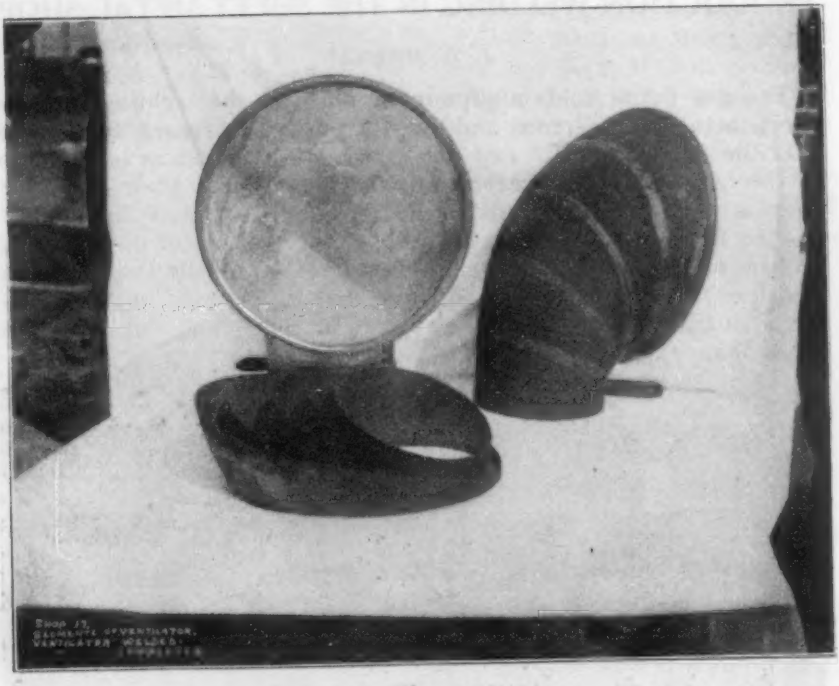


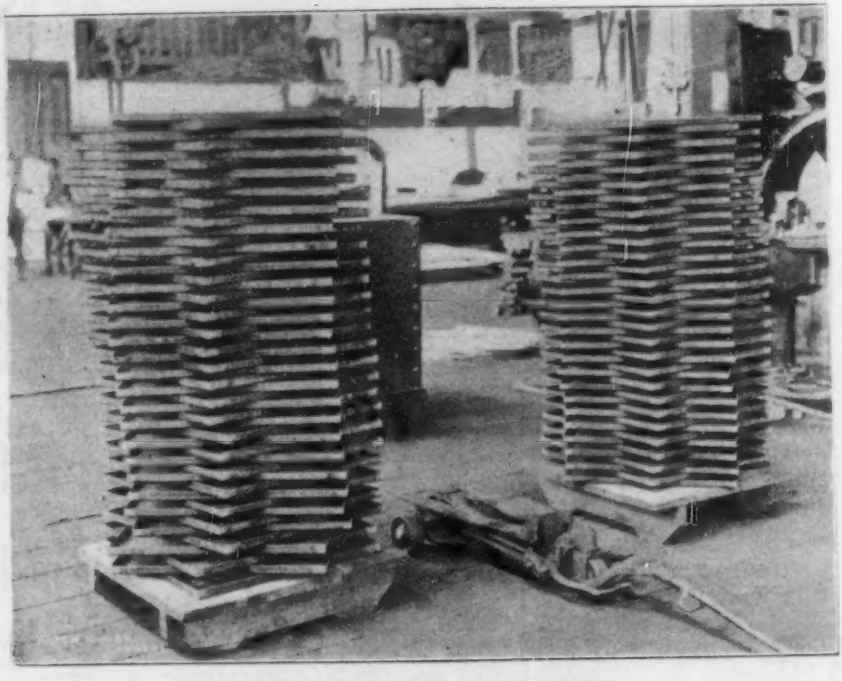
Fig. 1. Gasoline Tank Welded with Oxy-Acetylene Torch.

The Norfolk Yard, at the present time, uses the gas flame and the manual torch exclusively in its Sheet Metal Shop. In this Shop sheet metal up to $\frac{1}{8}$" thickness is handled.

The Yard manufactured the sheet metal furniture for all the battleships now under construction and a shop was equipped for this work.

*Welding Aide and Assistant Shop Superintendent, U. S. Navy Yard, Norfolk, Va.
Paper presented before New York Section, A. W. S., November, 1922.





Figs. 2 and 3. Welded Ventilator and Hatch Covers.

In the manufacture of metal furniture, it is necessary to produce a joint which is invisible and this can be secured by the gas flame, with or without a filler.

A slight corrosion is ruinous to sheet steel of the lighter gages and it has, therefore, been the practice in the navy, to stock this metal galvanized. However, due to the increasing amount of welding which is being done larger quantities of ungalvanized metal are being stocked and stored under cover.

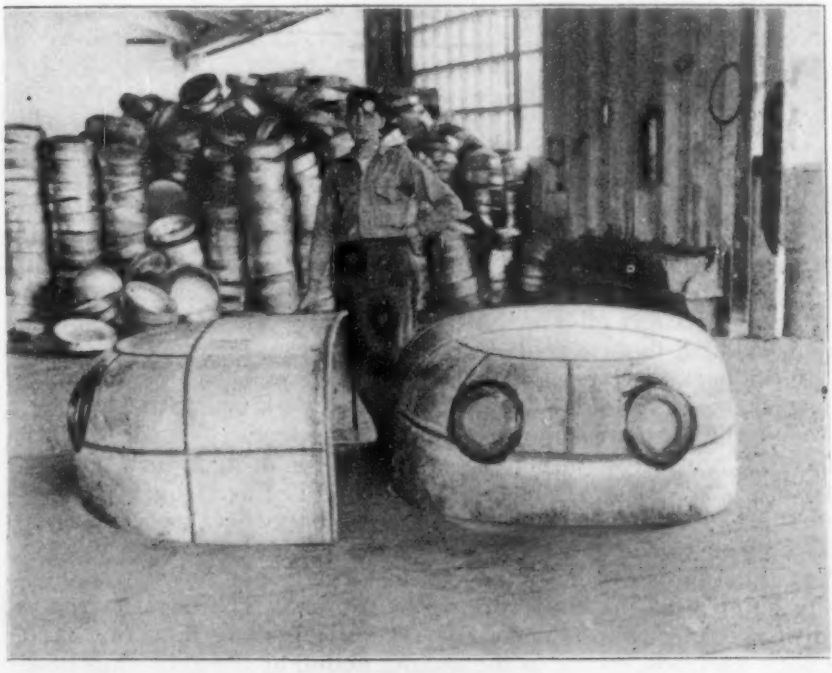


Fig. 4. Welded Dory Hood.

Galvanized material, due to the poisonous fumes given off during welding, is ruinous to the health of the operator. When it is used it is good practice to remove the galvanizing by immersing the joint edges in a solution of 10% sulphur acid, and then washing off the acid with lime water. The surface so treated will have to be protected in some way to prevent corrosion and paint is generally used, however, local tinning is sometimes advantageous.

The following figures give the extent of time of welding on several of the jobs illustrated:

The gasoline tank, Fig. 1 is constructed of No. 16 gage sheet steel. Twenty-five longitudinal seams 26″ long can be welded by one operator in 8 hours.

A 12″ Cowl of No. 18 gage sheet steel similar to Fig 2 and consisting of 6 segments can be welded without rim in 4½ hours. A

14" Cowl of 6 segments and similar construction can be welded and rim tacked in 7 hours.

One operator can weld the corners of 320 locker doors in 9 hours, when similarly stacked to hatch covers, shown in Fig. 3. The flange of the doors referred to is ¼" wide and there is about 1" of welding on each door.

50 Tool Boxes of No. 16 sheet steel, 24" long, 10" wide and 7" high having 56 linear inches of welding, including cover, can be welded by an operator in 59 hours.

Fig 4 shows dory hoods which were welded by the gas flame.

ELECTRODES

J. CALDWELL*

The first iron-arc welding was done with bare-wire electrodes. These are still widely used, and for some kinds of work where strength is not material the welds made may be satisfactory. With direct current operating on mild steel and wrought iron, flux- covered electrodes provide better results. For welding cast iron, high-carbon steels and alloy steels, and generally with alternating-current welding, flux-covered electrodes are necessary.

With bare electrodes there is oxidation of the electrode itself beyond the arc, and of the weld metal and work whilst they are hot. A suitable flux-covering protects the electrode beyond the arc, forms a protective slag on the deposited metal and work, and reduces the access of air to the arc itself. The arc length is somewhat greater and the current steadier, probably because the current is confined to the electrode end, and it cannot reach the outside. Manipulation is easier, as the arc can be struck on hot slag without any liability of the electrode to "freeze on." The deposit from a covered electrode on to a flat surface spreads more than that from a bare electrode, owing to the fluxing action of the slag, thus making a wider union and a neater finish.

Coated electrodes are essential for use with alternating current, probably because the coating and slag conserve the temperature during the periodic variations of the current.

The flux coating plays a very important part in welding high-carbon steels and alloy steels and cast iron, where it is necessary to obtain weld metal approximating in composition and structure to those materials. The electrode metal passing through the arc is considerably altered in composition; for example, carbon and manganese are burnt, or rather oxidized, by the reducing influence of the arc. The flux coating reduces the amount of this change, and may impart or restore the desired constituents. Whether this action takes place in the arc, or between the flux and the de-

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Extract taken from paper on "Electric Arc Welding Apparatus and Equipment," to be presented before the Institution of Electrical Engineers, England.

*Managing Director, Alloys Welding Processes, Ltd., (Manufacturers of Covered Electrodes).

posited metal, or partly in each, cannot be said. In the manufacture of steel the reactions between the metal and the flux in the furnace are essential parts of the process, and the composition of the flux is carefully adapted to the product desired. In arc welding, however, the time available for reaction is very short. This short time, the high temperature and the fine division of the electrode metal passing through the arc, are conditions widely different from those of the steel furnace, and a great deal of experiment has consequently been needed to arrive at the proper fluxes for different materials. In matching any particular steel the composition of the electrode and the flux co-operate. The electrode metal does not, as a rule, match that of the material. The work of producing electrode and flux combinations which will make good welds in different materials has met with great success. It has necessarily been done empirically, as no general principles can yet be formulated.

In the result, cast iron, manganese steel, nickel steel, stainless steel and other special alloy steel are all successfully arc-welded by the use of appropriate electrodes and fluxes.

For most purposes a flux coating of a basic nature is desirable, but in some cases it is of an acid composition. An aluminum wire or tape is sometimes included, and nickel plating is also used. Both these metallic additions tend, in different ways, to reduce oxidation of the electrode metal, and may also have other effects.

The metallurgical and chemical actions of the coating and the flux formed by it have to be reconciled with other requirements. The coating must fuse at a slightly higher temperature than the metal, while the slag formed must be very liquid and light so that it will rise to the surface before the metal solidifies and will spread over the hot weld and so protect it from the air. The flux should dissolve or reduce the iron and other oxides. The glassy skin of cooled slag should be easily removed from the welded surface by brushing or light hammer chipping, and the coating must be sufficiently tough and adherent to the electrode to withstand transport and handling. In working, the coating must fuse evenly without flaking and must keep level with the end of the electrode. There is usally a little "cupping," i. e., the electrode end is a trifle inside the fused rim of coating. Deep cupping is, however, objectionable, as a projecting rim of fused coating interferes with the arc striking and misleads the operator in respect to the length of arc. Whilst hot, the slag is a semi-conductor and the arc may be struck on it without any risk of the electrode sticking.

Intermediate between bare and coated electrodes are dipped electrodes, i. e., electrodes dipped into a "slurry" of a basic nature. This coating has some protective influence on the electrode as against oxidation, and reduces spluttering and current fluctuation as compared with bare electrodes. It is not a substitute for flux coating.

PROPOSED ROTARY SERVICE TESTING MACHINE FOR WELDED RAIL JOINT COMMITTEE

In order to give the industry an idea of the many problems confronting the Welded Rail Joint Committee, there is reproduced below a letter written by Vice-Chairman E. M. T. Ryder, to the Chairman of the Committee, Dr. G. K. Burgess, Chief, Division of Metallurgy, Bureau of Standards, and the discussion elicited from the members by this letter. Comments of those interested are invited. Replies should be addressed to Secretary W. Spraragen, 29 West 39th Street, New York.

Letter from E. M. T. Ryder to Dr. G. K. Burgess:

Your letter of the 19th is at hand bringing up the question of joints in the curved track on the proposed rotary service testing machine.

You inquire first, "if the welds are made by the Companies and shipped to the Bureau, are they to be made on straight or curved lengths." In reply, would advise that I think that the proper solution will not be exactly either of the alternatives that you suggest. When the joints are shipped from the railway company manufacturing them to the Bureau, I think they should be to the correct radius and ready to install on the rotary test machine. There are several reasons for this. If the joints were shipped straight, it would be necessary to have them curved on the ground by one of the Washington Railway Companies. While the Washington Companies might be willing to undertake this, it would be a rather difficult thing to do with those types of joints which have joint plates 2 ft. or more in length, and such bending after the joints are made might introduce additional strains in the joints which would effect their behavior under testing. Then again under actual conditions, joints are installed on curved track after the rail is curved, and it is desirable to follow the same practice with joints to be tested.

To follow out the above suggestion that the joints should be shipped to the Bureau already curved implies that the tested rails should themselves be curved by the rail manufacturers before they are shipped to the railway company making up the joint. Of course the rails could be curved by the railway companies, but their practice in doing this would show more variation than would the mill practice of the special work shops of the rail manufacturers.

There is unquesionably a disadvantage in the method proposed above in that it practically prevents these joints being made up in the street under normal track conditions, unless the railway company will have a 40 ft. radius curve where it would be willing to have the test joints installed and then cut out. Just how serious this objection is, probably depends on the particular type of joint considered. It is always desirable to have the abutting rail ends at the joint tightly closed and under compression if possible when

the weld is made, and it would be very difficult to obtain this condition with short pieces of curved rails set up on the shop floor.

However, speaking generally the importance of having the abutting rail ends tightly closed is greater than the importance of having them under compression which brings us back to the original statement in this discussion that the joints would probably be neither straight nor curved when shipped to the Bureau. What I have in mind is that all rail is ordinarily bent by putting it in the press which makes a relatively sharp bend at the point where the pressure is applied thru the ram, the final curve consisting of a series of these sharp points spaced fairly closely together with comparatively straight rail between. When the work is skillfully done as in the special work mills, the effect to the eye is a continuous curve, but especially at the end of the rail there is a short section where the rail is practically straight, as the distance between the supports in the press makes it impossible for the ram to be applied closer to the end of the rail then one-half the distance between such supports.

The suggestion I wish to make is this, that the ends of the two rails to be welded should be brought together after bending to make sure that there is no opening whatever on the outside of the head at the joint, which would mean that the rails would be kinked just beyond the joint plates, a little more than the theoretically necessary amount so as to give a straight chord in the curve across the joint for a distance of about 2½ ft. Theoretically this will effect the gage of the track a trifle less than ¼ in. This, I think, is negligible, as the gage can be held theoretically correct at the joint, and would be something less than ¼ in. wide beyond the joint plates on either side.

My personal opinion is that it will be found desirable to operate the rotary test machine with the flanges of the wheels turned off for two reasons. First, we would not wish to have the testing of the joints complicated by any flange wear on the joints, as they would theoretically not be subject to this on straight track. Second, it will very much simplify the aligning of the track on the machine itself as it will permit more variation from theoretical exactness than would otherwise be possible. It would also make unnecessary the great accuracy that would be required in constructing the machine itself if it were actually attempted to hold all the wheels in all the trucks so exactly to theoretical distance from the center of revolution as would be necessary to insure that the wheel flanges did not strike either head or lip of the girder rail on the 40 ft. radius curve. Of course it would be possible for the rail manufacturers to bend the rails to a continuous 40 ft. curve and then cut out from it the short sections of rail to be used in making up the test joints. This would give a curve thru the joint itself, but this would be objectionable for all types of joints using plates or bars, as it would not be possible to make straight plates to fit properly.

The middle ordinate for the chord 2 ft. in length being something over 1/8 in.

After the preliminary tests to determine the state of the art are completed, it will probably be advisable with certain types of joints, to have them made up by operators working in Washington instead of shipping all such joints from street railway companies in other cities. This will somewhat simplify the problem, as some of the joints could be made up in place on the track of the rotary machine itself. With certain types of joints, however, this will never be possible as they must be made where the equipment necessary for their construction is available.

The second question of your letter is, "can it be considered that a welded joint made in a short radius curvature rail will represent fairly the service that would be expected from a weld made on a tangent piece?" I think the question can be answered in the affirmative as far as the test on the completed joint is concerned.

As indicated above, however, it would ordinarily not be possible to make certain types of joint with quite the same theoretical efficiency on a piece of detached curved rail that would be possible to attain on tangent tracks. On the other hand, in other types of joints it might be that the laboratory made joint would be better than could be obtained under the normal operating conditions in the track. I believe, however, that these discrepancies will be so small as to have no material effect on the results of the tests.

DISCUSSION OF LETTER BY MEMBERS

D. D. Ewing, Professor Electric Railway Engineering, Purdue University, Lafayette, Ind.

I agree with Mr. Ryder that the joints for the rotary test track should be shipped to the Bureau, curved to the correct radius and ready for installation. There is no question in my mind but that curving the joints made in straight rail would induce such strains in the joints as to vitiate the test results.

Mr. Ryder raises the point that these joints would probably have to be made in the shop, as it is quite likely that the operating companies would object to making them on 40 foot curves in track now under operation. It seems to me that many of the objections to making the joints in the shop might be obviated by setting up a dummy track in which the conditions of abutting rail joints under compression or tightly closed, if closure only is desirable, might be easily obtained.

Also, I agree with Mr. Ryder that it will be desirable to operate the rotary test machine with flangeless wheels. It seems to be impracticable to try to construct the machine so accurately that the flange of the wheel would stay in the groove on the test track with the trucks running at high speed. Side-thrust from the flanges and impact blows on lip and head would be likely to occur if flanged wheels are used.

One other question, in connection with this machine, comes to my mind, and that is as to the type of sub-structure is used, I apprehend that it will be a matter of some difficulty to keep the running track in its correct position. On the other hand, if the track is rigidly mounted on concrete foundations it may be that the results secured will be materially different from what would be obtained in operation on standard track.

While Mr. Ryder's letter dealt only with the rotary service testing machine, I would like to take this opportunity to say that while a test track would probably give results more nearly in accord with what is obtained in actual operation, I do believe that joints, which stand up well on Mr. Wysor's proposed machine, will stand up well in service.

W. W. Wysor, United Railways and Electric Co., of Baltimore.

I thoroughly agree with Mr. Ryder that the rail containing the test joints should be shipped to the Bureau curved to the proper radius and ready to install on the test machine. However, I am not in accord with the suggestion that the joint itself be made straight and that additional curvature be added each side of the joint to compensate for lack of curvature through the joint itself. I believe that the entire rail lengths, including the joint, should be made to as nearly true radius as possible and I see no special difficulty about having the joint itself curved as well as the balance of the rail. I think it would be preferable, as Mr. Ryder suggests, that the rails be curved by the manufactures before shipping to the various companies who are to make up test joints, as some of the companies may not be so well prepared or be so skillful in curving the rails as are the manufacturers.

In curving rails, it is important that the head and base be kept in horizontal plane, and any one, who has had experience in curving girder rails, knows that there is a tendency for the rail to curve vertically as well as in a horizontal direction and that, in order to overcome this, it is necessary to first curve it in a vertical direction, or what we commonly call surface bending, so that when they are curved in a horizontal direction the final results will be such that the rail will lie in a horizontal plane. Experience and skill count for a great deal in curving rails to the proper radius and avoiding the more or less sharp bends, to which Mr. Ryder makes reference. By avoiding putting in too much bend at one time, and properly spacing the supports each side of the ram and putting the rail through the bender several times, thus bending it very gradually, it is entirely possible to curve the rail so nearly to the proper radius that the eye cannot detect any kinks and, for all practical purposes, the radius will be true.

In order to effect the curving of the rail through the joint, the rail should be first curved to the true radius and then sawed at the point where it is desired to make the joint. This will not only

give us the proper curvature through the joint, but it will also insure proper fitting of the two rails together and avoid an opening on the outside of the head, as would probably occur if we attempted to curve two pieces of rail separately. The extreme ends of the rails, which it is not practicable to curve, should be discarded. Joint plates should also themselves be curved to proper radius and by using the previously curved rail as a templet, the joints may be fitted very snugly. The curving of these joints could probably be facilitated by having the steel companies curve them in long lengths, before cutting them to the proper lengths for joints, or in case the curving is to be done by the railway companies, the joints could be shipped in long lengths and curved by the various companies and then cut to proper lengths.

It seems to me desirable that all portions of the track in which the test joints are located shall be equal distant from the center of the machine, so that any lurch of the trucks passing over the joints, due to change in the relative position of rail and wheels, with consequent uneven wear, may be avoided. This point may at first seem unimportant, and may, in fact, be unimportant, but, if we are going to use standard wheels, with cone shaped treads, there will, of course, be a change in diameter of the wheel every time it changes position on the rail.

I agree with Mr. Ryder that the flange of the wheels should be turned off, as they will serve no useful purpose.

As to the method of making up these joints by the various companies, I am not in accord with the thought that it is necessary that the joints be made in the track, and it would, in fact work a very considerable hardship on companies who did not happen to have a 40-foot radius curve available for this purpose. It would mean considerable additional expense to the company making up the joints, and it seems to me entirely unnecessary. Track conditions may be reproduced for all practical purposes in the yard, and I see no difficulty about putting the rails under compression. So far as our own practice is concerned, we use a joint plate with four holes, the outside two of which are punched somewhat eccentric with respect to the holes in the rail. The two center bolts are applied, but, before drawing them up tight, drift pins are driven through the two outside holes so as to bring the rails tightly together. Where this method is not used, the rails to be welded may be placed between buttresses of some sort and wedged together, so as to give them the compression equal to that which they would obtain in the track.

As to the question as to whether it may be considered that a welded joint made in a short radius curve will represent fairly the service that would be expected from a weld made on tangent track, I believe we may say that it will. Whatever the effect of curvature may be, it will apply to one type of joint as well as another so

that we may expect comparable results and, after all, that is what we are seeking.

W. F. Graves, Montreal Tramways Company, Montreal, Canada.

For comparative purposes, I see no reason why the joints should not be welded in a curve of the radius required by the testing machine. While this is, no doubt, unusual on any property because of the fact that curved rails are renewed more frequently than on the straight track, they are usually laid with a bolted joint.

It was the intention, as I understood it, to have the test joints welded by the various companies exactly as they were welded in the street. The welding of the joint on curved rail will, more or less, preclude this, as it would be necessary that the companies have a curve of the length and radius desired. This, also, is rather unusual, as the various spirals leading up to the curve make the central radius, as a rule, much shorter than 66 feet. It would, therefore, be necessary to lay this rail out and weld it under shop conditions. Also there would be more or less distortion, due to the application of the intense heat, which does not occur in the welding of straight track. However, all the above are only variations from practice in the street and for comparative results will probably make no difference.

The rail should be curved to the proper radius by the steel companies furnishing same and extreme care should be taken in butting the rails tightly together, and to prevent, as far as possible, any distortion in welding, the plates themselves should be curved to the radius of the rails.

H. H. George, Engineer, Maintenance of Way, Public Service Railway Company, Newark, N. J.

Speaking for the Loraine bar-weld type of joint which is one I am more directly interested in, I will say that it will be necessary to curve the rails prior to making the joints. In this connection, however, attention should be called to the fact that in practice, we do not weld any rail joints on curves of 40 foot radius such as is proposed for use in connection with the rotary testing machine. We certainly would not be willing to take out of a piece of curved track of this radius, a rail of the equivalent length of those to be used in making up the test joints and weld the experimental joints in the track in this way. If the joints for the curved track are to be made by us, they will be made by placing the two rails on the ties in a section of open track and welded in this position. I believe it would be entirely impracticable to bend the rails uniformly after the joints have been welded, and I also believe it would be very undesirable to attempt to bend such joints after the rails had been welded because of the additional resultant stresses which would be set up in the rails and joint bars. I believe that the rails to be welded for use with the rotary service testing

machine should be curved by the manufacturer prior to shipment, so that uniformity of bending will thus be assured. On most of the properties where these joints are to be made up, the bending would be done with either a Jim Crow type of bender, or with some form of hydraulic bender, as I believe but very few electric railway properties are equipped with a power driven rail bending machine, and in any case a good many companies would not have the bending blocks necessary for use with the section of rail in question.

As to the matter of discussion of whether the rails as actually curved represent a true curve or merely a series of short chords, I do not think that this is going to make any material difference in the make-up of the joints; although at present there is no question that the curved rail is composed of a series of short chords rather than a uniform curve, the actual difference between this and a true curve being so slight as not to have any appreciable effect in making up the joint. This comment is particularly true in the case of the Lorain bar-weld, more so, I assume than in the case of the channel bar joints where the question of fishing contacts enters in.

H. M. Steward, Boston Elevated Railway.

I am of the opinion:

1st, that the rails used for test purposes with the rotary service machines should be curved and shipped to Washington.

2nd, that at localities where the joints are to be made that the rails should be cut with a saw.

3rd, that the ends of the rails which will have been cut square by the manufacturer, be cut off and discarded; therefore sufficient rail will have to be shipped to make up for this waste.

4th, that the various test joints should be made at Washington.

5th, that the test joints to be made by the various people selected should be made by their own men, and not by a welder or a set of welders secured for the purpose.

6th, that the joints or bars used should be curved as well as the rail.

R. H. Findley, Supt. Track & Roadway, Omaha & Council Bluffs Street Railway Company.

It would seem necessary to bend the rails before making the welds for use in a 40 foot radius curve and they should not be stressed laterally thru bending after welding. On all joints where practicable it would seem best to bend a rail, saw and weld where the curve is perfect. In this way no opening will be possible between rail ends, and the joint can be drawn hair tight before applying any weld. It seems that plates may be slightly curved to meet the curved joint.

The joints tested in a curve of 40 foot radius should represent

in a fair measure the same conditions as are met in tangent track. However, the comparatively stiff construction which a curve has, precludes the possibility of much laterial deflection of the rails. On some types of rail—in fact on all rails, but to a different degree —we must contend with lateral strains, which with arc welded joints are important to provide against. The laboratory test of the rotary type would appear to favor these types of joints. I have noticed on tangent track with grooved rail, a general tendency on the part of arc welded seams, to loosen under the ball of the receiving rails. We attribute much of this to lateral flexibility of the rails, particularly if the rails are of a side bearing section.

Your vertical load and impact tests will be of great value; however, I think wheel conditions should be as nearly normal on the machine as we get in actual traffic—in fact why not let the wheel flanges crowd the joints part of the time if practicable, as we get this condition in operation. Most cars crowd either rail to some extent.

SMALL SCOTCH BOILER REPAIR

E. E. CHURCH*

During the war the U. S. S. Prometheus (the large repair ship of the Atlantic Fleet) was stationed at Brest, France, to keep up the repair work for the U. S. Navy. Along with her completely equipped machine shop and foundry, she had a complete welding shop, using the electric, thermit and acetylene welding.

During the summer of 1918, a small craft was in great demand by the army to transport men from the inner to the outer harbor for loading and unloading ships. Early in the summer one of the transportation officers of the army located a small tug, called the Trevona, which belonged to the French. He was told that the army could have the tug, providing they could get the repairs made, especially on the boiler.

Upon examination I found a small single end, one furnace Scotch boiler, with a wet back, the furnace being of the old straight tube type. At the back end of the furnace the plates had been corroded away until the thickness was less than one-eighth of an inch in places. This corrosion was confined to the lower half of the furnace for a distance of 14 inches from the back end.

The combustion chamber was rusted out at the bottom and up each side to near the center line. The back sheet was found to be in the same condition up to the center line of the combustion chamber. The boiler was setting on the bottom of the ship, with the back up against the bulkhead, dividing the boiler room from the

†Superintendent of Maintenance, University of Nebraska.

crew's space, making it impossible to get at the stay-bolts in the back or bottom of the boiler. At this point the boiler makers gave up, unless I would lift the boiler off of its saddle so they could get at the stay-bolts. The acetylene welders cut out the sheets and cut around each stay-bolt, leaving the stay-bolt in place in the wrapper sheet. After the old sheets were removed, and the edges of the good sheet chamfered, I had the boiler makers fit new sheets. Before setting these sheets in place, we electric welded each of the 24 stay-bolts to the wrapper sheet, to play safe against any possible leakage. We then set the new sheets in place over the stay-bolts, tacked them there, and then electric welded the seams and stay-bolts, (a total of 47 feet of seams and 24 stay-bolts).

The working pressure on the boiler had been reduced by the French engineers from 100 lbs. gauge to 60 lbs. gauge, on account of these bad sheets. We tested with water at 170 degrees F. and a gauge pressure of 150 lbs., and found everything tight, except for the sweating of two stay-bolts, which were rewelded.

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Extracts From By-Laws

ARTICLE I

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership. Annual dues $100.00

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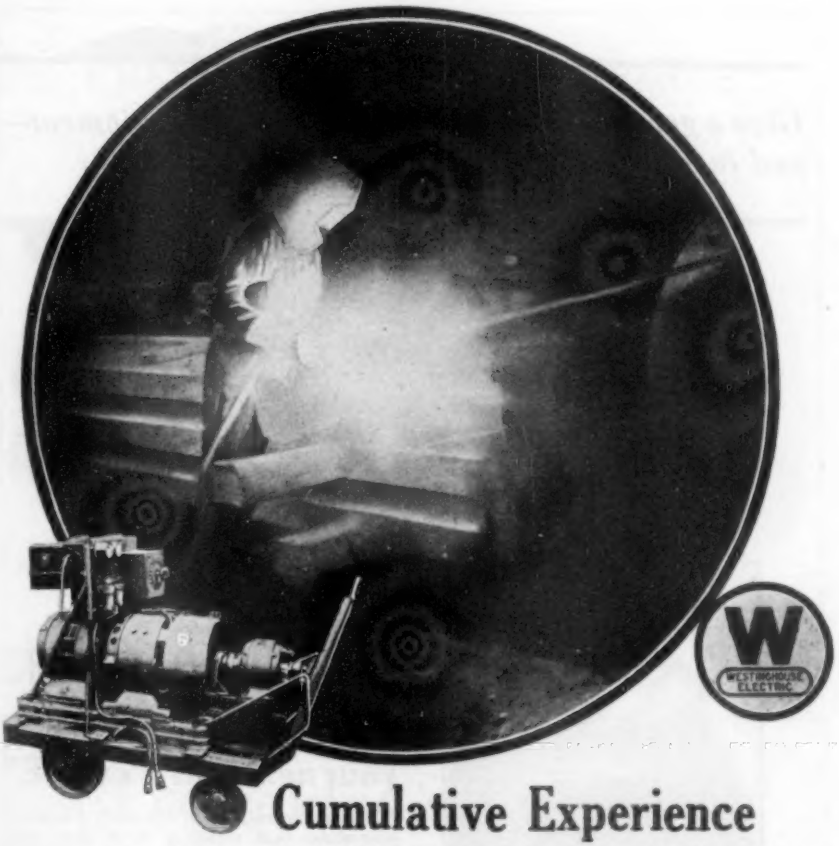

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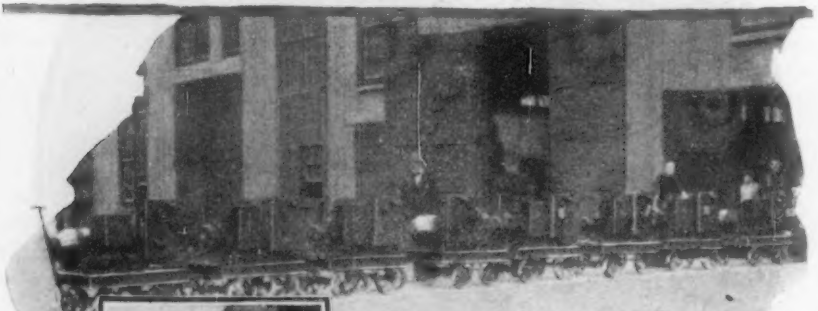

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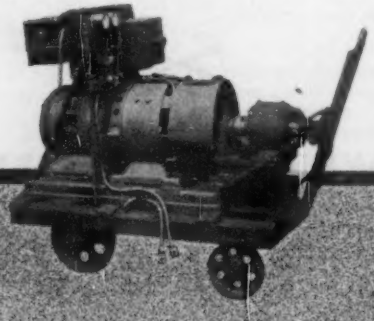

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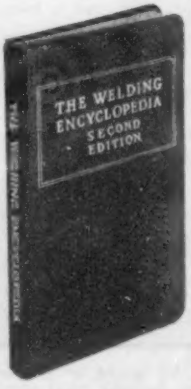

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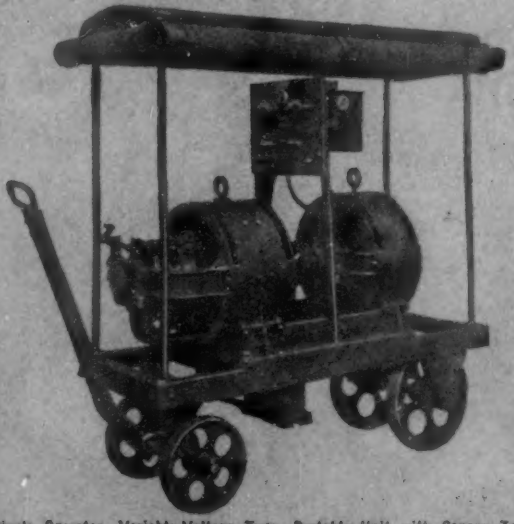

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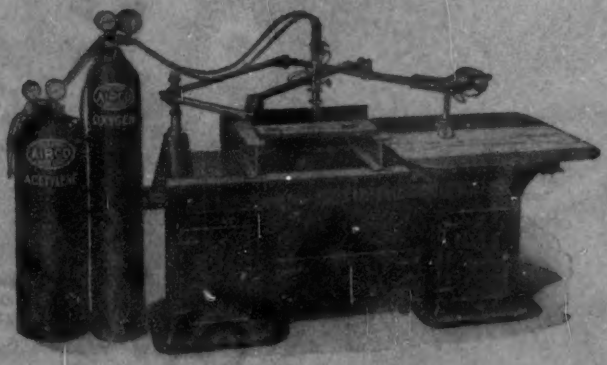

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